ADHESIVES AGE

MANUFACTURE, APPLICATION, TECHNOLOGY, RESEARCH AND MARKETING OF ADHESIVES

IN THIS ISSUE

SURVEYING MODERN ADHESIVES–A Review of Theory and Current Practice

BONDING MAGNESIUM TO PLASTIC FOAM–How to Attain Effective and Lasting Bonds

DISK SHEAR TEST FOR ADHESIVES–Determining Adhesive Shear Strength

METERING, MIXING AND DISPENSING–Automatic Proportioning of Epoxy Resins

OCTOBER 1958

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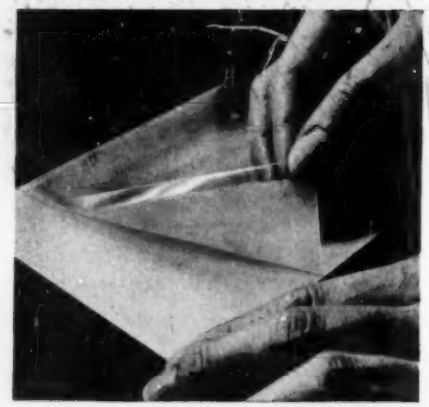

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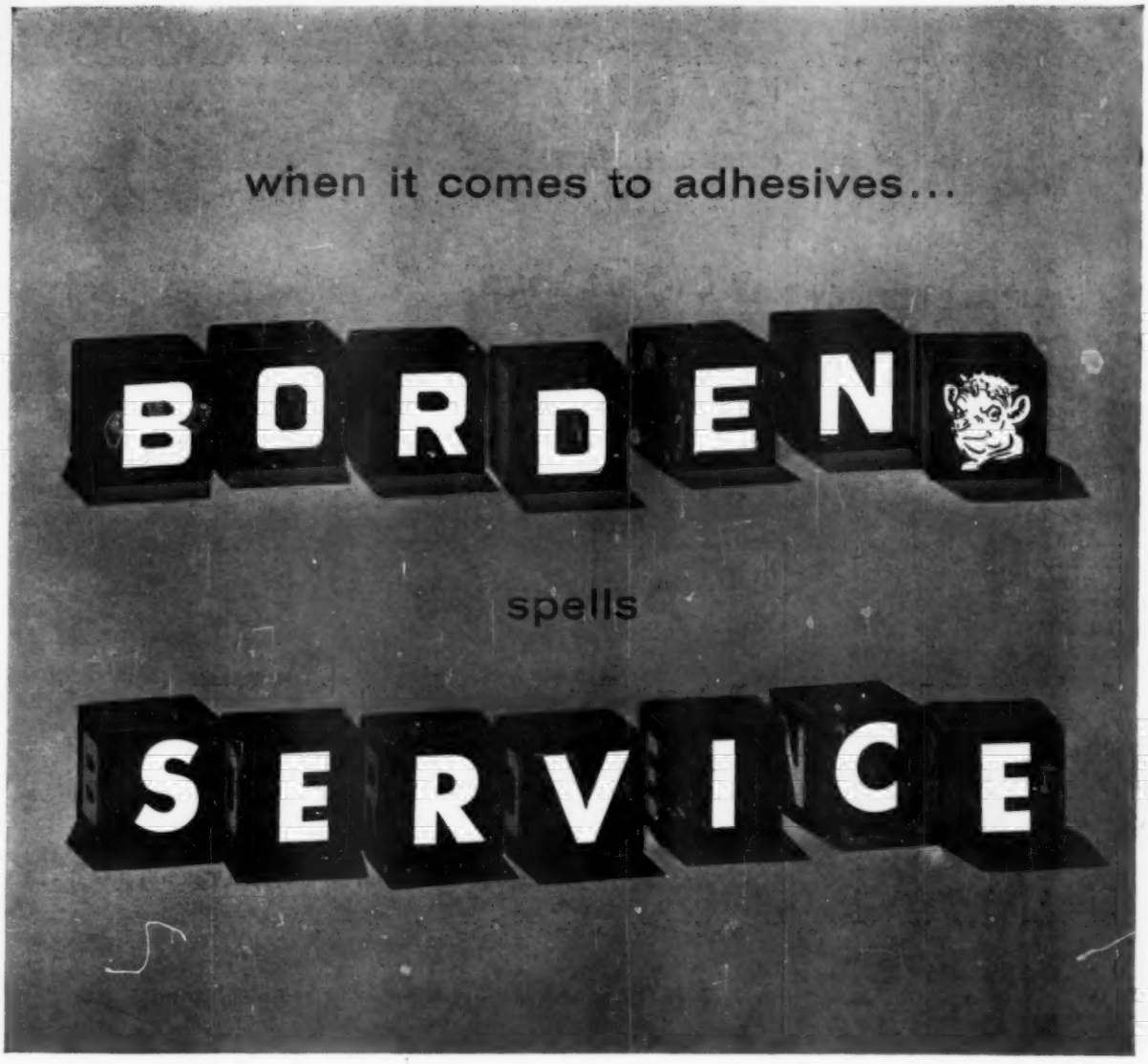

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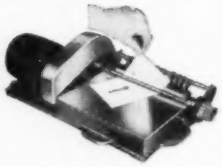

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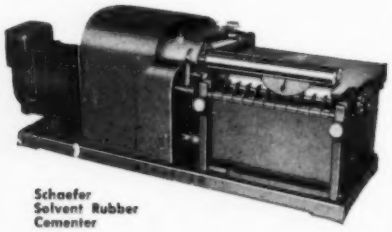

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ADHESIVES AGE
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Applied Science Dept.

OCTOBER, 1958 - 1959

VOL. 1, NO. 1

Summary

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23 How Strick Trailers utilizes film adhesives in the fabrication of skylight panels for its trailers.

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32 User-supplier liaison cuts adhesive costs up to 94 per cent in the bonding of magnesium to a plastic foam.

39 A precise method of determining adhesive shear strength through a relatively uncomplicated system.

Coming Next Month

How a new improved dextrine adhesive is permitting the Government of the United States to provide better postage stamps.

A comparison of tack testing methods for pressure-sensitive tape with a complete discussion of the phenomenon of tack.

An exclusive interview with executives of a leading adhesive company discussing the manner in which the company became active in its field.

Indexed in Industrial Arts Index and Engineering Index.

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NOV 24 1958

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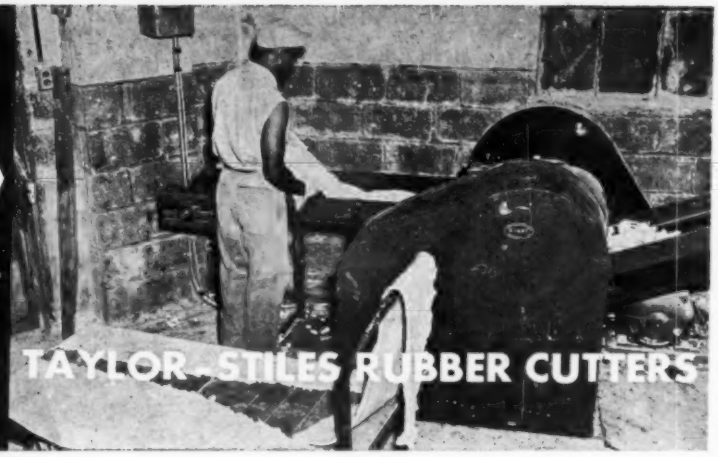

An important manufacturer of rubber adhesives made from synthetics and natural rubber formerly cut sheets of raw stock manually to ready them for churning. The work was slow and arduous. Quality suffered because undissolved rubber was filtered out. As a result the end product was not uniform.

After trying another make mechanical cutter which didn't work because the rubber wrapped around the knives, the manufacturer installed a Taylor-Stiles Rubber Cutter. The rubber was cut into small and even strips. Churning time was reduced 25%. Solvent losses have been reduced to almost nothing. And uniform quality has been assured since all the rubber is now dissolved.

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PUBLISHER'S STATEMENT

New magazines are introduced for a variety of reasons. Foremost among these is the realization that a need exists for the highly specialized and unique means of communication that only a trade publication can provide for the industry it is intended to serve.

In this sense, ADHESIVES AGE is no exception—other than the fact that the gestation period covered a span of more than ten years. Its publishers, who also publish the 42-year old RUBBER AGE and the 22-year old RUBBER RED BOOK Directory, long ago realized that adhesives and the materials that go into them and the processes by which they are made and the products they make possible were becoming more frequently the subject of feature articles. This was not only the case in our own journals, but also in many other publications far removed from the direct adhesives field.

In recent years, the volume of editorial material appearing on the broad subject of adhesives convinced us that sufficient interest in the subject had been generated and that the time had come to issue a journal devoted exclusively to adhesives. We recognized the need for a forum to be used by both manufacturers and users . . . the need for a business paper which would weld together the many elements and facets which make up the over-all field of adhesives. This is the raison d'etre of ADHESIVES AGE.

One of the first problems we encountered following the decision to publish an adhesives journal was: What is an adhesive? By chemical classification there are nine major *types* of adhesives, ranging from water-soluble gums to thermosetting and thermoplastic materials. The *scientific* definition given adhesives by A.S.T.M. is "any substance capable of holding materials together by surface attachment." Generally, cements, glues, mucilage and pastes are considered to be adhesives. But what about bonding agents? Sealants? And the many other materials which depend on *adhesion* for proper performance?

Based on extensive research and field studies, some of which we made and some of which were made for us, we believe adhesives fall into three specific categories. These are: (1) Any adhesive substance or method, other than mechanical, which bonds two materials together; (2) Contact adhesives, which cover pressure-sensitive goods, sealing compounds, and technical adhesive coatings, and (3) Vehicles for bonding fibers and particles of all kinds, such as non-woven fabrics, flock, ground cork, etc.

A second problem was: Who is an adhesive manufacturer? As a result of our extensive investigations we put such manufacturers into seven categories: (1) Manufacturers of adhesives of all kinds for sale as such; (2) Manufacturers of adhesives for combination with other materials to make finished products; (3) Manufacturers of adhesives for internal use; (4) Manufacturers of all types of sealing compounds; (5) Manufacturers of technical adhesive coatings; (6) Companies buying and re-packaging adhesives for sale; (7) Companies buying and re-selling adhesives in conjunction with related products of their own.

The adhesives industry has come a long way since technology became the basis for performance. Today, adhesives are called upon to perform spectacular tasks undreamed of only a short decade ago. We believe the adhesives industry, already a multi-million dollar field, is still in the embryonic stage . . . that we are on the threshold of advances which will carry the field into the billion dollar category.

We are firmly convinced that the adhesives industry is ready for a journal devoted exclusively to adhesive problems and we dedicate ourselves to the betterment of the entire industry. Toward that end, we shall be a means of communication . . . a common meeting ground on which adhesive maker and user may explore and solve problems of mutual interest.

M. E. Lerner
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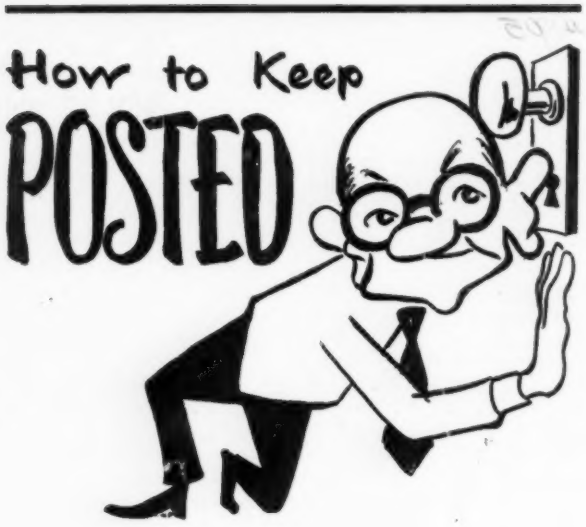

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CONSULTANT'S CORNER

By Dr. Irving Skeist

There are at least two parts to an adhesive bond—the adhesive and the adherend. It is important that they be compatible if their marriage is to last. The *adherend* or *substrate* may be a smooth sheet of steel, aluminum foil, paper, wood veneer, plastic film, plate glass; it may be the fibers of a tire carcass, a felt for non-woven fabrics, glass cloth for a reinforced plastic boat; it may consist of particles of abrasive in a grinding wheel, wood chips in a building board, or rock aggregate in a road surface.

Particular Problems Cited

Glass fiber, bonded with resin to make boats, pipe, room dividers, sports car bodies, etc., presents a different set of problems. The cheapest resins that are generally satisfactory are the unsaturated polyesters. But these are lacking in specific affinity for the glass, and tend to shrink away from the fiber upon curing. The voids thus created are weak spots in the structure. One remedy is to apply a *finish* to the glass, a special type of hybrid molecule which ties in with the glass at its "polar" end, and with the resin at its "non-polar" end. Another solution is to utilize epoxy resins, which adhere better and shrink less. Price of liquid epoxies has just been lowered 20%, bringing them closer to the polyesters in cost.

Different again is the problem of encapsulating glass vacuum tubes in miniaturized electronic components. Whatever extremes of temperature may be encountered, the potting resins must adhere to the glass to keep out moisture and preserve good electrical characteristics. Flexibilized epoxies provide one answer.

Glass as an Adhesive

Finally, glass may switch roles and become the adhesive. Glass frit, carefully compounded for specific adhesion and rate of thermal expansion, gives metal-to-metal bonds which resist the high temperatures encountered in jet flight. To form a more perfect union, adhesive and adherend must be matched to each other.

Special Note

Readers of ADHESIVES AGE with problems relating to the manufacture, application or use of industrial adhesives are urged to send their inquiries to the editor. Each month in these columns, Dr. Skeist will answer your inquiries. Readers will not only find solutions to many vexing problems but also valuable "tips" on many day-to-day situations. Address the Editor, ADHESIVES AGE, 101 West 31st Street, New York 1, N. Y.

CONSULTANT'S CORNER

The *adhesive* may be a starch derivative, glue, asphalt, rubber, resin, sodium silicate, cement, etc., alone or in combination. Some of these terms cover a variety of products; a score of resins have important adhesive uses. In physical form, it may be a latex or solution from which water or solvent must be evaporated; it may harden from a liquid to a solid without formation of volatiles; or it may be solid already, requiring heat to fuse it. Some adhesives consist of a single component, while others—especially among the newer, stronger resins—are in two parts which must be blended shortly before use.

Some adhesives are useful with a variety of adherends. For miscellaneous home duties, polyvinyl acetate is superseding glue and dextrin paste. In the workshop, the epoxies show versatility as bonding agents. But do not try to stick everything together from a single glue pot. Instead, the adhesive should be matched to the adherend. There should be *specific* or *chemical* attraction between adhesive and substrate, not merely mechanical entrapment of the adhesive. The nature of adhesive bonds is currently undergoing much examination and clarification by chemists and physicists. For the adhesives user, these urgent explorations in many laboratories will result in better end products.

Glass Bonding Treatments

Glass is a good example of a material which requires many different bonding treatments. First is safety glass, a sandwich of two sheets of plate glass enclosing a thin layer of tough, resilient, crystal clear plastic. Glass and plastic must be bonded together so firmly that if the glass is cracked, the broken pieces will be held securely by the plastic sheet. In the early safety glass laminate, cellulose nitrate—"Celluloid"—was the interlayer. It tended to yellow and delaminate because of the action of light. Cellulose acetate, developed in the 1920's, was an improvement. Later, especially in England, middle layers of acrylic resin came into use because of their superior light stability. Today, the preferred interlayer is polyvinyl butyral, judiciously plasticized; it is excellent in both adhesion and light stability.

About the Author . . .

Dr. Skeist, associated with Skeist & Schwarz Laboratories, Inc. of Newark, N. J., is a graduate of Worcester Polytechnic Institute, having received his Ph.D. in polymer chemistry from Brooklyn Polytechnic Institute. He was associated with Celanese Corp., Newark Paraffine & Parchment Paper Co., American Molding Powder and Gering Products before becoming a consultant in 1954. The author of many economic studies, review papers and patents on plastics, plasticizers and polymers, he is currently completing a book on epoxy resins. He is also a member of the American Chemical Society and The Association of Consulting Chemists and Chemical Engineers, Inc. Dr. Skeist is a Fellow of the American Institute of Chemists and of Sigma Xi, and a member of the Commercial Chemical Development Association, Chemical Market Research Association, Phi Lambda Upsilon, Society of Plastics Engineers and Society of the Plastics Industry. He is also visiting professor of Physical Chemistry of Polymers at Stevens Institute of Technology.

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Emulsion Adhesive

No. 2135 is a synthetic resin emulsion adhesive used for fast bonding of porous surfaces such as cardboard and has a high degree of water resistance as a dry adhesive bond. It is recommended for sealing cardboard and paper boxes or cartons, especially where water resistance of the bond is a problem. This adhesive is especially useful for bonding of knocked-down corrugated cardboard boxes, since it develops its grab faster than animal glues and has better maximum strength. Automatic box making machines produce excellent results with No. 2135 adhesive. Available in 5 gallon pails and in 55 gallon drums, it can be applied by roller coating, brushing, knife coating or spraying. *Dennis Chemical Co., Inc.* P-2

Polyethylene To Brass Adhesive

A new adhesive reportedly able to resist a pull of 1,000 psi is being used to bond polyethylene directly to brass, brass-plated metals, and rubber. It is based on a compound described as partly hydrogenated polybutadiene, which is vulcanized by the addition of other materials. Any degree of unsaturation of the polybutadiene from 3 to 30 per cent is reported to provide excellent adhesive action. Temperatures from 250 to 350°F. and pressures of 100 psi or less are required for bonding. A layer of the adhesive 2 or 3 mils thick is desirable. This layer can be brushed or sprayed on, or inserted between the materials to be bonded as a thin, prefabricated sheet. Possible uses include bonding of polyethylene to brass in submarine cable amplifiers for underwater phone cables, linings for tanks and plating racks. *Bell Telephone Laboratories.* P-3

Epoxy Adhesive Pack

Storage and mixing of epoxy resin adhesives has been made easier and cleaner with a new "Adhesive Pack". These adhesives must be mixed at the point of use and kept free from contact with the skin and contaminants. In the new pack, these two problems are solved with two clear plastic containers connected by a short length of plastic tubing. One chamber contains a glass ampoule filled with the prescribed curing agent; the other has the basic epoxy adhesive. To use, the glass ampoule is broken, releasing the catalyst to run into the chamber containing the adhesive. A nylon mesh strainer prevents glass particles from being transferred to the adhesive.

Fenwal Adhesive Pack

While still completely sealed, the resin and agent are mixed by hand kneading. The degree of mixing is conveniently observed through the clear plastic. After mixing, the connecting tube is cut and the adhesive is extruded by hand pressure onto the area or part to be repaired. Since the glass ampoule contains the precise proportion of agent, there is assurance that the exact amount of curing agent is used for the specified epoxy. *Fenwal, Inc.* P-4

Helix R-823 Bonding Agent

A 100 per cent pure epoxy compound, "Helix Bonding Agent R-823", has been found to offer many advantages in bonding optical filters and test charts. Two components, consisting of a background mask and a test pattern plate, were bonded emulsion to emulsion. Optical clarity, ease of handling, low viscosity, and hardness without brittleness when cured, were given as some of the advantages of R-823. *Carl H. Biggs Co.* P-5

Resin For Neoprene

A heat-reactive phenolic resin for use in neoprene adhesives is claimed to make possible the production of solvent-type neoprene adhesives with the highest heat resistance available on the market today. This property, combined with fast air-drying, and cohesive as well as adhesive properties, permits formulation of superior heat-resistant neoprene cements, according to the firm.

Soluble in aromatic, aliphatic and ketone solvents, heat-reactive "SP-126 Resin" is said to be compatible with both neoprene and nitrile rubber. It is produced in lump form and has a melting point of 145-165°F. Neoprene solvent adhesives containing SP-126 Resins are said to be useful for bonding glass, steel and non-porous surfaces to themselves or to each other. Such adhesives are used in the shoe industry for bonding shoe soles and in many other industrial applications. *Schenectady Resins Div., Schenectady Varnish Co.* P-6

Fiber Flock Adhesive

"Forever White" can be used as an adhesive for all man-made fibers, plastics, metal flitters, cork, mica, or other materials normally used in decorating fabrics. The adhesive is resistant to washing and will not yellow on storage or after launderings. The films formed are flexible and easily cured at low heat in 15 minutes to one hour and will cure in a few minutes at high heat. *Lucerne Industries Corp.* P-7

Eccobond 26 Patch Kit

A new epoxy resin patch kit that has recently been placed on the market finds use in many important industrial applications such as repair of tools, hardware items, furniture, boats, and in particular as a handy

Eccobond 26 Patch Kit

bonding agent at the laboratory bench or on the production line. The kit is supplied as a two-part system in two separate tubes. Equal amounts of resin are squeezed out, mixed, and applied. Cure is complete in four hours at room temperature or in minutes at 150°F. The cured resin forms a permanent part of the repaired item. It is chemically inert and physically very strong. *Emerson & Cuming, Inc.* P-8

Liquid Sealing Compound

"Rubba-Seal", a liquid plastic sealing compound which prevents leaking of metal milk boxes, window flower boxes, ash cans, waste paper baskets, etc., is a clear transparent compound with excellent adhesion to metal, wod, fabric, cork, leather and other surfaces. It is particularly useful for metal items which are fabricated only with spot welding. Rubba-Seal is easily applied by brush, spray, or flow gun. *Rubba, Inc.* P-9

Contact-Pressure Epoxy

"Maraset Resin No. 532," a versatile, general-purpose epoxy compound has been announced. Applied in a thin layer, this new high-strength adhesive requires only contact pressure for a durable bond that will not delaminate even under heavy duty. It has marked resistance to water, chemicals, and solvents.

Primarily developed for joining metals, the new resin has shown superior results in bonding other materials and combinations of materials—including glass, plastics, wood, and masonry. Reinforced with fibrous glass cloth, it is an efficient medium for the repair of tanks and vessels.

A two-component system, the epoxy adhesive is effective at high as well as moderate temperatures, depending on the curing method and the Marblette hardener used. For general requirements, it is blended with "Hardener No. 37" and cured at room temperature overnight, or at 200°F. for one hour. For high-temperature applications, it is mixed with "Hardener No. 38" for a heat cure of three hours at 180°F. followed by three hours at 250°F.

An aluminum-to-aluminum bond created by Maraset Resin No. 532 has demonstrated tensile shear strength of 2,000 psi after a room temperature cure, and 3,800 psi after a single-hour heat cure. Seven-day tests showed the 3,800 psi strength maintained after immersion at 77°F. in water; 3,300 psi in hydrocarbon fluid; and 3,100 psi in JP-4 fuel. *Marblette Corp.* P-10

Adhesives for Furniture

Two new adhesives, "Gimptex" and "Weldbond," have been developed for use by furniture manufacturers. "Gimptex" permanently bonds fabric gimp to furniture. It is a quick drying, permanently flexible adhesive which does not crystallize or become tacky with age. It may be easily applied with a squeeze bottle. With "Weldbond," it is now possible to adhere plastic and leather welting to furniture. It has excellent aging qualities and has withstood Fadeometer and Weatherometer tests without signs of discolorations to plastic or leather. *Anchor Adhesives Corp.* P-11

Marine Plastic Resin Glue

Boat owners will be interested in a new marine grade plastic resin glue that is also effective for cabinet work, hobbies, general furniture and door manufacturing. This new easy-to-mix powdered glue has a shear test of 3,500 psi. It can be mixed with water or with resin modifier to eliminate crazing and shrinkage. *Wilhold Products Co.* P-12

FOR MORE INFORMATION on the new adhesives described here, use the Reader's Service Card elsewhere in this Issue.

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COMING SOON

The editors of ADHESIVES AGE have selected a great variety of articles for publication in future issues in order to provide the widest possible coverage of the vast adhesives industry. Watch for these articles scheduled to appear shortly.

- **The British adhesives industry—manufacture and application**
- **How to dry mix basic resin adhesives**
- **Methods for measuring adhesive tack—a review**
- **Uses of epoxies and silicones in adhesives**
- **Rheology and electrokinetics of adhesives**
- **Tackiness of liquid adhesives during roll application**
- **Production problems minimized for adhesive container labeling**
- **Defoaming agents and the application of glue in large amounts**
- **A new process for constructing integral wing fuel tanks**
- **How the government uses adhesives**
- **Resin adhesives for palletizing operations**
- **Bindery adhesives find wide use at United Nations**
- **Adhesives for the food processing industry**
- **Animal glues find use in uranium reclamation**

These and many other interesting articles will soon be in print

ADHESIVES AGE

101 West 31st Street, New York 1, N.Y.

capitol cues

INFLATION IS NOW THE BIG WORRY of government officials and business economists—in contrast to three months ago when fear of a slump was very widespread. It's a new kind of inflation: Recovery has only just started and there's plenty of goods about; but money is tighter and the price-wage spiral that began with the war seems to be getting another lease on life.

> What makes this inflation so hard to understand—and hard to deal with—is the fact that it's a psychological phenomenon. People have now come to accept steady inflation as a normal part of life; they have seen unions and industry push prices up in bad times and good. So even a slight business pick-up sets off inflationary fears. Then there's a flight from the dollar—a preference for things that pushes prices up and up.
>
> Already, psychology has pushed many stock prices up to record levels, and made industry less fearful of marking up steel, aluminum, and cloth prices. Unions now hint that they'll ask bigger wage increases to make up for recession marking-time.

THE INFLATION PRESENTS BIG PROBLEMS for individuals and government. They must decide whether it is only a temporary thing—likely to dissipate in a little while when the psychology changes—or the start of a long-term uptrend. At stake are the businessman's profits for perhaps several years to come...the investor's nest egg...and the economy's over-all stability.

- Business must choose between plunging ahead on inventory or bigger plant—or waiting to see if the inflation will wane. (Most economists feel this is a time to be long, not short.)
- Investors must chose to buy stocks or real estate now or hold devaluing cash, waiting for a shakeout that may never come. (If you can wait for growth, even high prices will pay off.)

NEW STEPS TO TIGHTEN CREDIT are on the way. Officials are watching things closely—making policy day by day, as inflation developments dictate. Chances are they'll raise the official discount rate again—maybe to 2½%. (This is the rate that banks pay when they borrow from the Federal Reserve, and it was already raised once, in mid-Summer.) The Reserve will take steps to see that banks don't get as much new money to lend as they had last year at this time. Before long, interest rates may be back up near 1957's peak.

WATCH EARLY SALES OF 1959 CARS FOR A TIP-OFF as to how fast the rise in business activity will go—and how far inflation fears will be realized. If the new models get a warm reception, then get set for a nice little boom—in appliances and other hard goods, too. If the reception is only luke-warm, then the recovery will still be brisk, though it won't rate the word "boom."

Best forecasts as to the 1959 auto year read like this:

- New cars may hit a 6-million car level, tops. More likely, the figure will be 5.3 to 5.5 million. (1958? 4.3 million.)
- Used cars will be in tight supply, and prices will be firm. Many who might normally buy a new car, will take a used one..

Continued on Next Page

capitol cues

THIS IS A GOOD TIME TO REVIEW INVENTORY POLICIES, say many business forecasters. In their view, many firms are in danger of being caught short this Fall. Retailers' stocks are, on the whole, slightly lower than a year ago. Manufacturers' holdings of many items are way down, so retailers will have trouble getting delivery on rush orders, if sales pick up. And sales are expected to increase smartly in the final months of this year.

FIRST FORECASTS OF BUSINESS IN 1959, now being made by economists, show a year much better than this one—a year of faster-than-average growth. Virtually all of the things that determine trend will be pluses—government spending...consumer spending, especially for durables...and business outlays for new plant. (This last may ease some early in the year but should be on the rise by the second half.) Some analysts even see the possibility of a new boom, though the only-mediocre prospects for autos weigh against this.

Here are some basic trends foreseen for next year:

- Production will regain 1957's peak levels some time in the course of the year. The gain will be some 7% over today's.
- Employment will run 1.5 million workers higher. The gains will center in construction, retailing, and the services.
- Unemployment will still average 4 million or more. Some 700,000 new workers will replace many of those rehired.
- Wages will increase by more than this year's average of 9¢ an hour. The number of workers benefiting will be up, too.
- Prices will rise 1% to 2%, despite some leveling in food.

Total output of goods and services—Gross National Product—will increase to almost $460 billion in 1959. That will be about 6% greater than the $433 billion expected this year.

THERE'S STILL HOPE FOR LEGISLATION UNPASSED in the closing days of the past session of Congress. Measures of concern to many industries stand a good chance next year, though they will have to start from scratch, with hearings and committee drafts in both houses before floor votes. Many bills had strong support from lawmakers. But they were blocked by disagreements over details, which couldn't be resolved before adjournment rolled around.

Some of the more likely candidates for passage:

- Labor regulation will be voted with curbs on racketeering—especially if the Senate Committee keeps turning up dirt.
- Mineral subsidies are a good bet. The Administration likes this better than the tariffs and quotas otherwise needed.
- More housing money will be voted, since the various housing agencies are running out. The money stimulates business.
- A minimum wage hike will be pushed again and, in the more liberal atmosphere of 1959, might just make it to $1.25.
- Minor tax changes will deal with excises, loopholes, and a proposal for extending fast depreciation to used equipment.

Some controversial bills probably won't pass in '59, either—school construction, limits on powers of the Supreme Court, and reductions in individual or corporate income tax rates.

Among new business to be taken up next year will be anti-inflation action, a farm law with still lower price props, and development capital for Latin America and the Mid-East.

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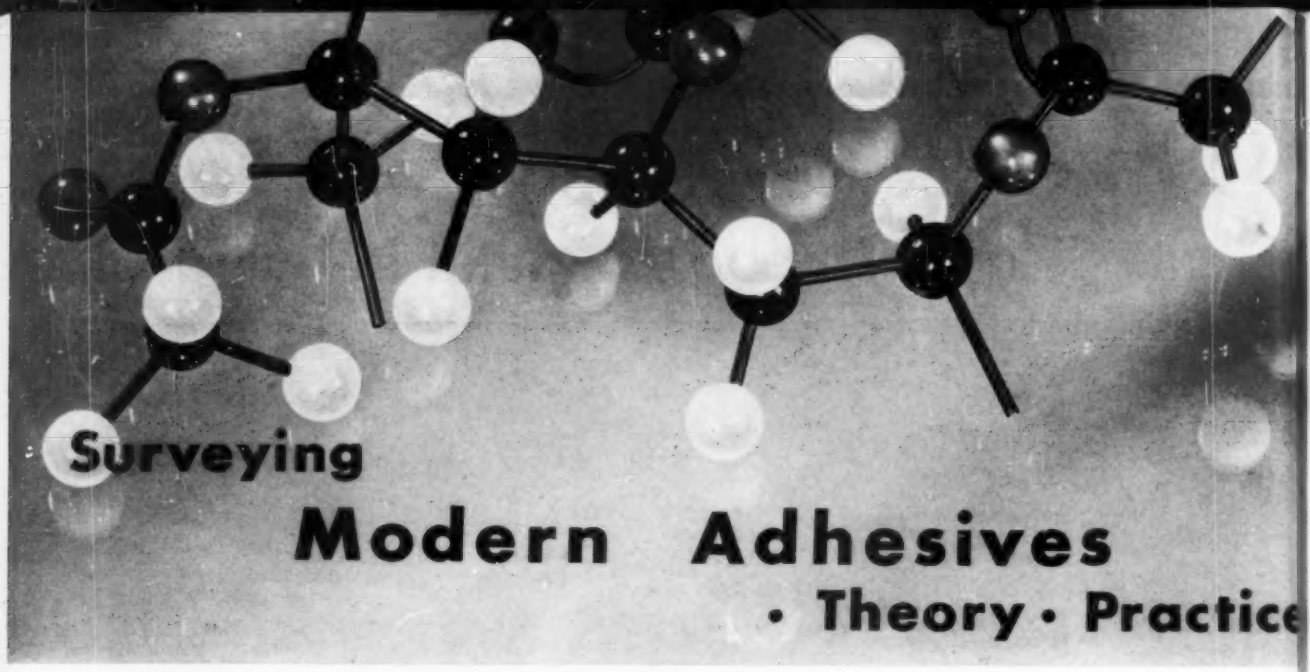


Surveying Modern Adhesives • Theory • Practice

By EDWARD BEARMAN
Technical Manager, Eastern Division, Morningstar-Paisley, Inc.
New York, N. Y.

The past four decades have seen adhesives emerge from the paste and mucilage stage—with materials little different from ones used since antiquity—and enter a new era where existing products were revolutionized and new adhesive materials utilized. Rare is the industry today that does not use an adhesive as part of its manufacturing operation. The advances of the adhesives industry have paralleled those of the aircraft industry: just as supersonic jets have replaced the undependable, slow single-engine biplane, super-speed adhesives of natural and synthetic origin, with scientifically built-in properties to do a specific task, have almost completely pushed aside their simple forerunners. In fact, it was the early aircraft industry, with its problems of materials-fastening, that spurred research in the adhesives field in 1920, the year that marks the birth of the modern adhesives age. Today, adhesives continue to serve modern aircraft, with the latest resin adhesives even replacing rivets and thus serving to drastically reduce air friction.

Accelerated research has unearthed the chemical and physical properties of thousands of adhesive formulations. As a result, the adhesive manufacturer can accurately predict the behavior of a material for a particular application and thus recommend the proper adhesive. This knowledge has made it possible to use adhesives in applications generally deemed fantastic just a few short years ago. For example, adhesives are used today in bridge construction, building construction, and even for seams in wearing apparel. In addition, this research has helped make the tremendous packaging field what it is today, with adhesives available to bond paper and paperboard, plastic films, and metallic foil—all on automatic packaging equipment—to form packages that seal the merchandise contained therein.

Since bonding is the basic function of an adhesive, it has been important to establish the chemical and physical forces that cause two surfaces to stick together. A number of investigators have advanced some useful explanations of adhesive behavior, which have allowed adhesive manufacturers to modify their products to meet specific needs.

Present Adhesive Theory

Present theory explains adhesion as the result of specific attraction caused by chemical, physical, and electrical forces. The adhesive process includes wetting of the combined surfaces by the liquid adhesive; hardening of the adhesive through evaporation of the liquids, penetration into the adherend fibers, or chemical action; and finally, complete hardening or setting of the material, where it develops its maximum tensile strength and bonding power.

An adhesive placed between two solid surfaces should completely displace the air contained between the two materials. The amount of air displacement is dependent upon the degree that the adhesive wets out the adherends. Ideally, the liquid should form a contact angle of approximately zero degrees with the solid surfaces (lies flat on the solid surface). Wetting, and air displacement, are caused primarily by molecular attractive forces that retain the liquid adhesive in extremely close contact with solid surfaces. Adequate wetting of the surfaces to be joined is, therefore, of vital importance in getting the required bond.

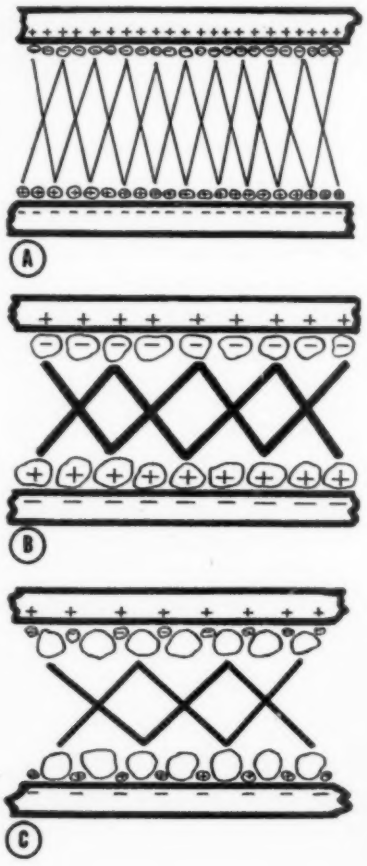
The adhesive process can also be explained in a slightly different fashion. When a liquid adhesive is applied to a surface, constant molecular motion (Brownian movement) causes large polymerized molecules from the adhesive solution to migrate to the solid surface. The same motion then causes the long molecular chains in the adhesive to attach themselves to the solid surface. The requirements for permanent attraction or adhesion are: (1) complete wetting of the substratum by the adhesive,

A long molecular chain of polyvinyl acetate, as shown in the illustration behind the title, is formed by uniting single molecules of vinyl acetate to create a long chain polymer so valuable for use as an adhesive. This water-soluble material is then subdivided into particles of microscopic size and then permanently suspended in water. The resultant emulsion is an ideal form for most application methods.

and (2) complete absence of an incompatible surface film.

Adhesion and bond strength are greatly affected by the molecular structure and polarity of both the joined surface and the adhesive material.

Molecular weight is important in the effectiveness of an adhesive. In the schematic sketch: (A) Shows a material with very low polymerization, and relatively small molecules. Polarity, and therefore specific adhesion, is high, but there is little cross-linking with resulting low viscosity



and tensile strength. (B) Represents a material with a high degree of polymerization. Large molecules have low polarity and low specific adhesion, solubility, penetration, and wetting. Large degree of cross-linking, however, provides high tensile strength. (C) Represents an intermediate degree of polymerization with a broad range of molecular weights. This condition provides a desirable combination of properties. The small molecules furnish high specific adhesion and the large molecules supply the forces needed for high tensile strength.

In general, compounds with disorderly molecular arrangements — starch, dextrine, proteins, and synthetic resins—make better adhesives than those with an open straight chain of carbon atoms. The former have common characteristics of being polymers and they have long molecular chains which are sometimes cross-linked by secondary valences or bonds. According to some researchers, these chains are oriented perpendicularly to the plane of the adherend surface. As a result, there is a strong clinging action between highly reactive molecular groups at the ends of the chains and the surface of the solid adherends.

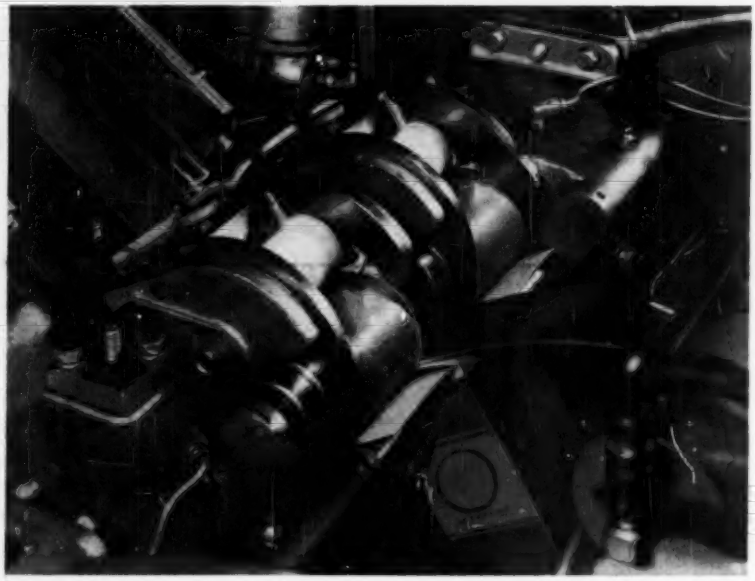
Concept of Polarity

The concept of polarity assumes a prominent role in the function of an adhesive. A polar compound possesses an electric moment. One basic rule of adhesion: If simple unmodified substances are used as adhesives, polar adhesives should be used with polar adherends, and non-polar adhesives with non-polar adherends. For example, wood can be successfully bonded with urea formaldehyde resin, a highly polar material. Reason: cellulose, one of the basic constituents of wood, is polar because of the OH groups that protrude from the molecule. However, when wood is heated in a dry atmosphere, it seems to lose its polar characteristics, and urea formaldehyde will no longer provide a satisfactory bond to the heated wood. During the heating process, adjacent hydroxyl groups lose water and are converted into weakly polar ether groups with less attraction for the urea formaldehyde resin.

Molecular weight, an important consideration in the effectiveness of an adhesive, goes hand in hand with polarity. For example, an unpolymerized compound has the smallest molecules, but the greatest mass concentration of polar groups. Therefore, viscosity and tensile strength are at a minimum, but solubility is high and specific adhesion potential is at a maximum because of the high polarity. On the other hand, a completely polymerized resin is solid and devoid of strongly polar structures except for the end groups, which represent only a minute concentration. Although the adhesive layer would have great tensile strength, specific adhesion would be low, and solubility, penetration, and wetting would be at a minimum.

The golden mean, therefore, is usually the best rule to follow in compounding an adhesive—with an intermediate degree of polymerization in resins, an intermediate degree of degradation in dextrines, and an intermediate degree of gel strength and viscosity in animal glues. In addition, a broad range of molecular weights is usually superior to a closely fractionated cut of molecules with the same weights. This condition provides a desirable combination of properties: The relatively

Toys, games, and hobby craft products are assembled and fastened with versatile resin adhesives because they hold securely to so many different surfaces and materials. The pictured material, laminated with a resin adhesive, is used to make a variety of toy tents.



Strong, deep bonds of resin adhesives allow the manufacture of sanitary milk containers. Adhesives used for this purpose have to be odorless, non-toxic, non-staining, resistant to lactic acid, and water resistant.

small molecules wet out the adherend readily and, by permitting adsorbed air to be displaced easily, can penetrate rapidly into the adherend. The larger molecules present in the compound, although contributing only slightly to specific adhesion, increase setting speed and provide the tensile strength required.

Tackiness

Tackiness is another important factor in the functioning of an adhesive. This property holds the bonded surfaces together while the adhesive achieves its final set. It can be defined as the resistance that must be overcome when separating two solids joined by an adhesive still in its liquid state. If a sphere or ball made out of asphalt or rubber is placed on a plate made from the same material, and pressure is exerted on the ball perpendicular to the plate, the sphere will gradually merge into the plate. Thereafter, any attempt to remove the sphere by an upward pull will result in the production of a filament—not the original sphere. In addition, a considerable force is necessary to draw the filament out of the material, a force much larger than the surface tension to be overcome.

Tackiness exists when: (1) the materials merge rapidly at room or slightly elevated temperatures, and (2) they show a resistance to forces of stress and shear if an attempt is made to separate them again. The quality of tackiness in a substance can disappear completely at sufficiently low temperatures. For example, a solution of rubber in benzine, very tacky at room temperature, becomes hard and brittle at the temperature of dry ice. Therefore, heat, with resulting molecular motion, is essential for tackiness.

Conditions favoring tackiness or merging are: temperature increase, degradation to break down the degree of polymerization (starch to dextrine) and increase polar group concentration, and the presence of a solvent or plasticizer. Conditions hindering tackiness are: temperature decrease, cross-linking of molecules, and crystallization.

Film Thickness

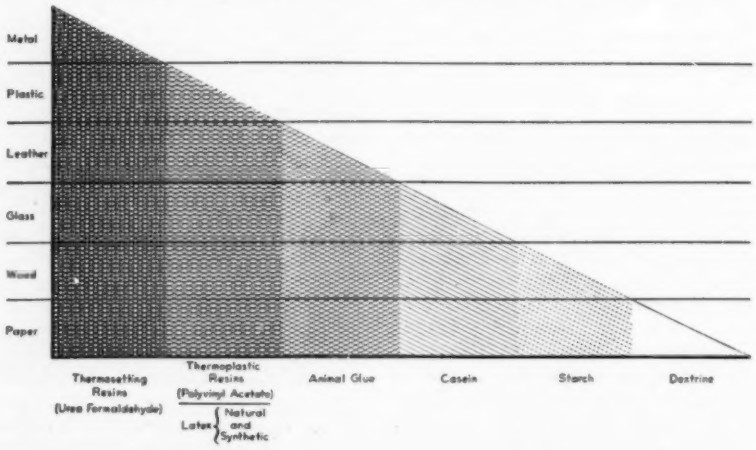
The thickness of an adhesive film will determine its effectiveness. In general, it has been established that the joint strength of any adhesive system is inversely proportional to the thickness of the glue line, provided that a sufficient quantity of adhesive has been applied to insure film continuity. This phenomenon is due to the greater probability of flaws in thicker films, just as a long length of fiber will have a lower breaking strength than the average of a number of shorter lengths.

Selecting the Proper Adhesive

Three basic factors have to be considered in order to select the proper adhesive for the job at hand: (1) the adhesive must stick to the bonded surfaces, (2) the liquid adhesive must have the physical properties to meet the method of application, and (3) the bond must be sufficiently resistant to external forces to stand up for the periods of time under the required use and/or existent storage conditions.

The adaptability of the adhesive to the surface may be illustrated by comparing the wide variance between an adhesive used to laminate metallic foil to paper for a Christmas wrapping and the trowelling cement used to bond vinyl tile to a cement floor. Several different classes of adhesives, thousands of different formulations within these classes, are available to

Selecting the Proper Adhesive for the Job at Hand



do an effective bonding job for specific materials under varying conditions.

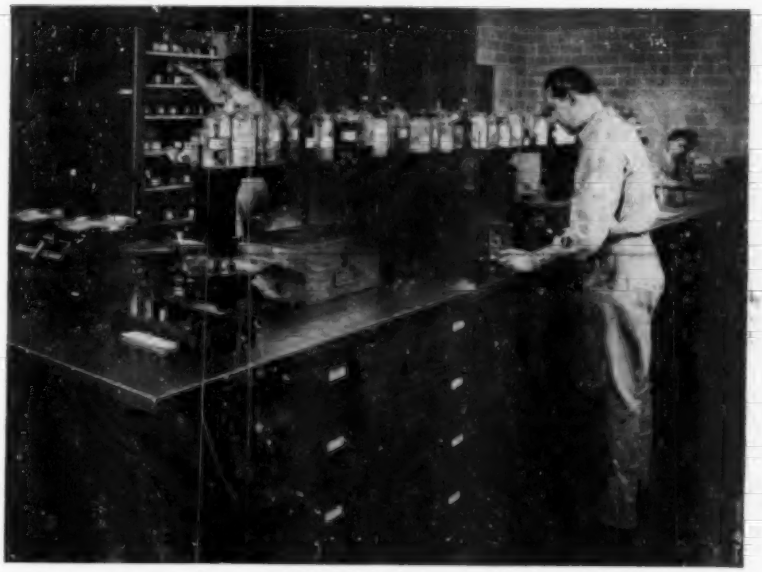
Numerous methods are available by which to apply adhesives. They can be applied by direct and transfer rollers, mechanical stencils, brushes, spray guns, trowels, etc., either by hand or machine. To meet the needs of the application method, the adhesives manufacturer must adjust the flow, deformation, viscosity, drying speed, and tackiness of the adhesive. For example, a short buttery paste with moderate drying speed is required to adhere the bottom seam on a paper bag. On the other hand, the long seam on the same bag requires a fluid, fast-setting, syrupy type of adhesive. Thus, although the same basic paper surface is being bonded, the adhesive ingredients must be compounded differently to meet the requirements of the application method.

Endurance of the bond to the conditions to which it will be subjected is also a very important factor in choosing the proper adhesive for a particular job. For example, a bottle labeling glue used for affixing a beer bottle label has to stand up under refrigerated conditions, or even submersion in ice-cold water for several days. The adhesive film on an envelope seal must not become sticky and prematurely seal the envelope when the atmosphere is hot and humid. And a book adhesive should retain its flexibility and dimensional stability for an indefinite period of time.

To meet all these requirements, the adhesives chemist has at his command a number of film-forming materials that he can compound and modify. A film former is the basic ingredient chiefly responsible for the dual functions of adhesion and tensile strength. These film formers may be starch, dextrine, natural gum, animal glue, casein, resins, and natural and synthetic rubbers and others. Each of these materials has its own peculiar characteristics, and each can be modified to obtain many desirable properties.

Starch Adhesives

Starch adhesives have been used since the ancient Egyptian civilization period; however, a number of advances in starch technology in recent years have made this least expensive of adhesive products applicable for an increased number of uses. Starches used in modern adhesive formulations are usually tapioca, corn, sago, potato, and wheat. In its unconverted form, starch is essentially insoluble in cold water. However, when cooked with 10 parts of water to about 170°F, it forms a soft paste with low tack and weak adhesive properties.



Accelerated research in the modern adhesives laboratory has allowed the adhesives manufacturer to accurately predict the behavior of an adhesive for a particular application. As a result, the fields of usefulness for adhesives have been increasing continuously at a fast pace.

When starch is roasted by itself or in the presence of an acid catalyst, it is degraded into a substance known as dextrine. This product has greater solubility than starch in either cold or hot water. Adjustment of the roasting process will provide an almost infinite variety of dextrines with solutions of varying viscosities and degrees of tack. The higher the solids content of the dextrine solution, the greater its tack and stickiness. Thus, by roasting starch for a sufficiently long period of time with the proper catalyst, the adhesive manufacturer can produce dextrines which are practically 100% soluble in cold water and which will produce fluid, tacky solutions with solid contents as high as 75%. This type of dextrine-based adhesive is commonly used in the manufacture of postage stamps and envelopes.

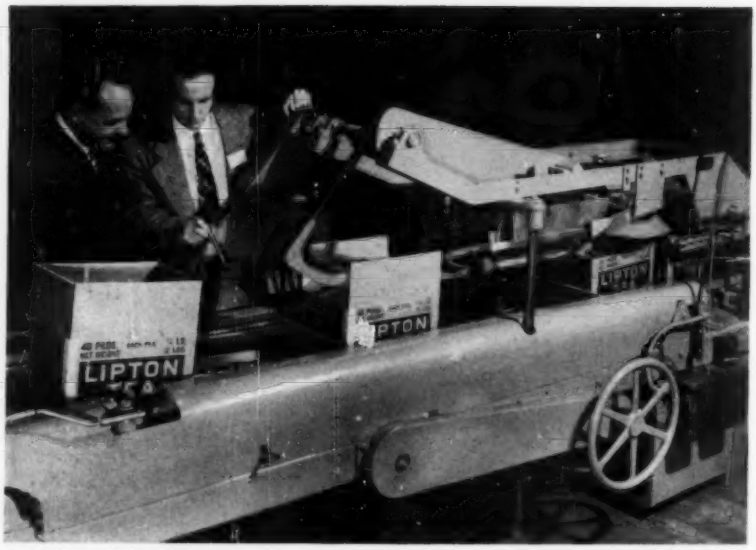
Ingredients that are commonly present in starch and dextrine adhesives are alkalis, plasticizers, solvents, modifying agents and preservatives. These products help to impart the desired properties to the adhesive. Alkali products make dextrine adhesives tackier, heavier, and gummier. Plasticizers make the adhesive film more flexible, prevent distortion of the glued surfaces, and control the drying speed. Stabilizers in starch and dextrine solutions prevent the paste from becoming excessively heavy during prolonged storage. Preservatives prevent bacterial degradation.

Major uses for starch and dextrine adhesives have been for bonding uncoated paper and paperboard to similar products or to glass, and for school paste, envelopes, bottle labeling, paper tubes, bags, and the manufacture and sealing of corrugated and solid paperboard containers.

Starch Processing

Recent improvements in the processing of starches and dextrines are enabling today's vegetable adhesives to attain higher standards of uniformity. Therefore, these adhesives are more uniform from batch to batch with consistent machining quality for long periods of time, which allows the user to take full advantage of the speedier operation of modern machinery.

Even the precise genetic origin of the starch and its reaction to dextrinization processes are taken into consideration and utilized to obtain the desired effect in the adhesive. The starch-producing vegetables are now being grown under controlled scientific agricultural conditions. As a result, starch-based adhesives have improved color or clarity and stable viscosities under adverse machining



Dextrine or resin adhesives are used for case sealing, with resins furnishing the fastest speed. The unit shown above is the Elliot Model A Automatic Case Sealer, on which one roll applies adhesive to the inner or end flaps of the case. Only one set of rolls is used for the top and one set for the bottom. Use of a segmented glue roller prevents the application of adhesive between the flaps.

conditions, plus a controlled rate of penetration into porous materials. In addition, the newer chemical additives, stablizers, preservatives, and plasticizers are contributing to better adhesive and mechanical properities.

Great advances in recent years have been made in the development of pre-cooked or drum-dried starch and dextrine adhesives. Shipped in dry form, these products reduce freight costs in export shipments. They also furnish an economical adhesive solution that can be reconstituted with a large amount of water. These pre-cooked products are more stable in storage for a longer period of time. When no cooking facilities are available to handle cook-up dextrine adhesive types, the pre-cooked variety is certainly ideal.

Another innovation in starch adhesive chemistry has been the modifications of the chemical structure of starch to obtain improvements in viscosity stability of starch and dextrine solutions. One of the resulting products, a class of starch ethers, is finding increasing use, particularly in bag adhesives, display mountings, remoistening glues, and paper packaging adhesives. Starch ethers have good fluidity and high water-taking ability, factors that mean more economical operations. They also have less set-back or pastiness, a disadvantage of ordinary starches.

Animal Glues

Another category of adhesives is based on fish and animal glues, proteinaceous substances derived from the extraction of bones, hides, and scrap leather. The raw material is usually supplied to the adhesive manufacturer as granules or powder, which are only slowly soluble in cold water. However, when cooked in water, it forms an extremely tacky solution, which solidifies and gels when cooled. Animal glues are available with a wide range of properties and are classified by viscosity of a 12½% solution at 140°F and the strength of their gels on cooling. They are designated as hide or bone in origin. The chemical additives are usually plasticizers such as glycerin or extenders such as cane sugar and certain salts.

Animal glues are distinguished by high tack and tensile strength. Adhesives based on animal glue are generally run as hot solutions, and produce a bond much more rapidly than dextrine products. Their very strong holding action is based on a double-barreled approach: (1) they set rapidly because of quick moisture loss, and (2) they gel very rapidly on to a drop in temperature. Fields where animal-glue-based adhesives are being used are luggage, woodworking, and bookbinding, where advantage is taken of the high degree of tensile strength and tack.

Casein Adhesives

Another important protein base for adhesives is casein, a complex protein obtained from milk by acidification or by treatment with the enzyme rennet. Casein is insoluble in water but can be dissolved by treatment with alkali solutions. There are two basic types of casein glues. The first is usually supplied as a powder containing casein, alkali, and calcium oxide. When mixed with water, it forms a viscous solution because of the solubilizing action of the alkali. The calcium oxide reacts slowly and forms calcium caseinate, which causes the solution to become progressively heavy and eventually form an irreversible gel. This type of casein is used, for the most part, as a water-resistant wood glue. However, its short working life and susceptibility to spoilage after mixing with water are serious disadvantages and, to a large extent, synthetic resins have supplanted it.

The second class of casein adhesives, which does not contain any added calcium salts, does not gel in solution. However, its films do have limited water resistance. A volatile alkali such as ammonia used as a solubilizer will gradually be lost in the dry glue, and the film will not redisperse readily in water. This property is an advantage in the formulation of bottle-labeling adhesives where resistance to immersion in water is desirable.

Rubber-Based Adhesives

Rubber-based adhesives, both synthetic and natural, are supplied as solutions in solvents such as hexane or as water-borne latices. Rubber adhesives are characterized by great pliability and a high degree of specific adhesion. They can be formulated to produce dry films with permanent tack or stickiness, such as in cellophane tape. They can also be made into films with no residual tack but with strongly cohesive properties.

Natural rubber has the unique property of producing a non-sticky film that will form an immediate bond when it is brought in contact with another natural-rubber film. This type of film is used on both the flap and body of an envelope to make a pressure-sensitive seal. Important uses of rubber-based adhesive are in flooring and structural cements and in the manufacture of foil and plastic-film laminates. However, odor is a problem that makes this material unsuitable for many food packaging uses when it is used as a foil laminate.

Synthetic Resins

Another class of adhesive, rapidly becoming more and more important, is synthetic resins, which are rapidly supplanting many of the types mentioned previously. Synthetic resin adhesives, available since about 1937, were discovered through research on the structure of natural adhesives such as starch, dextrine and animal glues. Since natural adhesives have molecular shapes similar to fibers of cellulose and wool, very long and narrow, adhesive chemists began a search for chemicals with molecules that could be joined together to form these long super-molecules, or high polymers.

Once the technique of developing high polymers was discovered, the adhesive chemist could produce vast differences in products by changing chemical composition, or by changing the size and shape of the molecules. This process is polymerization, where two or more molecules of the same substance, or of different substances, unite to give a more complex long-chain molecule. The resulting polymer has the same percentage composition as the original substance, but the molecular weight is often many hundreds of times as great. Through such a method, the adhesive chemist started with a monomer such as vinyl acetate, which has no adhesive value in itself, and polymerized the compound to polyvinyl acetate, a long-chain molecule with a very definite adhesive value.

The great majority of resin adhesives in use today employ as basic raw materials the same high-polymer synthetic plastic compounds that go into useful products for the home and industry. These plastics include urea formaldehyde resins, vinyl resins, polystyrene, acrylic, ethyl cellulose resins, and others.

When they first came into use, resin adhesives were dissolved in organic solvents, and as a result, they were inflammable and often toxic and odorous. They had many other disadvantages such as poor machining qualities and flow, slow setting speeds, and high cost. Nevertheless, the solvent types of adhesives were used in large quantities for many years because they could bond a great number of difficult surfaces impossible to bond with vegetable and animal glues.

It was the task of the adhesive chemist to combine the desirable properties of both the water and solvent base adhesive into a single product. The answer was the emulsion type of adhesive, in which the chemist found a way to subdivide the water-insoluble adhesive materials into particles of microscopic size and keep them permanently suspended in water. Since then, emulsion adhesives have grown constantly in scope and variety to meet a great number of industrial applications and performance results impossible to attain with other forms of adhesives.

Forms For Adhesive Application

Form	Film	Major Uses
Water Dispersed	Starch, dextrine, casein, animal glue, natural latex, PVAc, GR-S, neoprene, acrylic, Hycar, urea and phenolic formaldehydes.	Packaging, woodworking, luggage, envelopes, laminating
Lacquer	PVAc, nitrocellulose, natural and synthetic rubbers.	Structural, laminating, foil, plastic film, impermeable surfaces
Pressure-Sensitive	Natural and synthetic rubbers, gutta percha.	Tapes, labels bandages
Hot Melt	Thermoplastic resins (PVAc, ethyl cellulose, polyamides), waxes, gutta percha, asphalt.	Can labelling, tear tapes, bonding impermeable surfaces, blister and skin packaging
Liquid Resin (100% Active)	Epoxy, polyurethane, silicone resin.	Metal, glass, wood, plastic, concrete

Two Resin Classes

The two major classes of synthetic resins can be designated as thermoplastic and thermosetting. Thermoplastic resins soften with the application of heat. Polyvinyl acetate is the most important member of this group. Thermosetting resins, on the other hand, harden irreversibly with the application of heat because of cross-linking and polymerization and are usually used with a catalyst. Urea formaldehyde, phenol formaldehydes, and the epoxy resins are important members of this group of materials.

Polyvinyl acetate adhesives have practically revolutionized the adhesive industry in the last twenty years by their ability to bond difficult surfaces with tremendous speed and efficiency. The polyvinyl acetate emulsions, fluid in their original form, are water-borne systems containing approximately 55% solids. The emulsions are compounded further by the adhesives manufacturer to develop the physical and adhesive properties required for a particular job.

One of the most important advantages of this polyvinyl acetate resin adhesive base is its completely synthetic character, which allows most of the essential characteristics to be built and predicted. For example, setting speed and rate of penetration of the adhesive into the substrate can be controlled by varying the particle size of the dispersed resin. Water resistance and mechanical stability are functions of the emulsifying systems used. High-speed packaging machines, which usually exert a very strong and constant beating action on the liquid adhesive, would coagulate the emulsified resin if the mechanical stability of the emulsion were low.

Molecular weight and degree of polymerization control tensile strength of the bond as well as rate of penetration and specific adhesion. In addition, polar groups are easily introduced into the molecule by copolymerizing with acids such as maleic. The most prominent end uses for polyvinyl acetate adhesives include: furniture, paper cups, frozen food cartons, milk containers, bags, plastic films, bookbinding, and general household cements.

Thermosetting Types

The thermosetting types include formaldehyde, phenolics, and epoxies. Urea and phenolics are used

principally as wood glues. Phenolics offer the greater degree of water resistance. Both of these products are usually applied as water-borne solutions of the resin which is still in a relatively unpolymerized state The addition of a catalyst to the solution prior to bonding and the application of heat to the assembly results in a rapid cross-linking and polymerization in the glue line. The polymerized resin is so extensively cross-linked that it is permanently insoluble in practically any solvent and is, to all intents, infusible.

Epoxy Suitability

The epoxies are fairly recent in origin. They are usually supplied as 100% active viscous materials that contain no added solvent. Consequently, there is no film shrinkage on drying, which makes them ideally applicable for structural uses. These resins have many polar groups extending from their molecules, a composition that provides very favorable specific adhesion properties. Metal bonds of extremely high strength and durability have been produced with epoxies, and their uses have been expanding generally, and especially in the aircraft industry. However, the need for a catalyst and heat are disadvantages of some epoxies, just as with the ureas and phenolics.

Within these classes of film formers, or adhesives, a number of new developments has occurred recently. Incorporation of new additives for plasticizing, stabilizing, etc., have increased the number of uses of these existing products. For example, a new series of resin adhesives for bonding metallic foil to paper and paperboard was recently developed. It is expected to replace the latex type of foil laminating materials, whose odor makes them unsuitable for food products. As a result, the number of foods that can be packaged in foil strengthened with a paper backing will be greatly extended.

Thermosetting Adhesive

Another resin adhesive recently developed is a thermosetting adhesive for plywood that meets all present commercial requirements for exterior use, is stable at room temperature, and cures readily. This material was developed as a result of work on chemicals made from wood bark. In a development for the food canning industry, a new adhesive allows the labeling of cans in a temperature range from 40°F to 160°F. Previously, the canners had to shut down the line when cold cans from storage required labeling when hot cans were going through the line. The adhesive in the gum box had to be removed, the gum box cleaned out, and a new adhesive put in that would be effective with the cold cans.

Inorganic Adhesives

The major adhesive based on inorganic chemicals is water glass, or sodium silicate solution. This material is applied as a liquid: on setting it crystallizes into a glass. This factor, however, is one of its basic disadvantages, because glass particles constitute a hazard when the seal is broken. It is slowly being replaced by dextrine types of adhesives for this reason. The major use for sodium silicate is in the sealing of cases. It is also sometimes used in the manufacture of spiral and convolute paper tubes, such as cores for paper towels.

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Adhering Truck Trailer Skylight Panels

How Strick Trailers Uses FILM ADHESIVES to Facilitate Skylight Assembly

Strick Trailers is engaged, through its subsidiary, Strick Plastics located at Perkasie, Penna., in molding structural reinforced plastics for its trailers; the vacuum forming of large doors and liners, and other smaller parts of plastic. Ultimately these are installed in the finished trailers.

Previously, a plastic skylight was installed by riveting it to the roof at the sub-assembly station. This was a costly operation which resulted in a seal which was not entirely satisfactory. (There are panels available which claim to be plastic-bonded-to-metal types, but these seem to have a tendency to leak and have very poor joint adhesion.)

It was obviously necessary to develop a method and an approach which would circumvent all these problems. The Strick men searched and chose an adhesive which could be applied by brushing and "laying on." This was sought in order to achieve better control and positioning and still be carried out at a place not far removed from the press. (Spraying defeated this aim.)

Creating a Sandwich

In the bonding of the skylight, a sandwich is created. This consists of aluminum, a film of adhesive, and the polyester reinforced plastic sheet. When heat is applied in a press, the process is completed. A liquid primer is used for the purpose of insuring a better bond. The entire process—as outlined in pictures which follow—is obviously an effective and efficient one. The steps follow:

Aluminum sheets, 26 x 96-inches, are blanked out in quantity with two openings of 14 x 25-inches. The preparation of the aluminum, adhesives and plastic sheet is performed on opposite sides of the heating press so that two crews of two men each can use the press alternately.

One operator cleans the aluminum blank with a solvent to remove all oils and dirt (Fig. 1). Using a template, he scribes lines to indicate the area within which the primer will be applied and the blank is brush coated with the liquid primer (Fig 2). Using a blanked aluminum sheet as a template, the reinforced plastic sheet is placed over it and cleaned with an acetone solvent (Fig. 3). This dries almost immediately and the liquid primer is applied. A three-inch band can be painted on all sides and down the center by following the aluminum below (Fig. 4).

Now the adhesive, which is supplied in rolls three inches wide, is placed on the plastic (Fig. 5) in much the same way as one would apply masking tape. However, this is *not* a tape. It is a liquid in dry film form. When it is in this form it isn't tacky, it is easy to handle, and doesn't flow. Film adhesives are becoming more and more important in such applications. Its advantages are many. For example, in addition to ease of handling, accuracy of placement and other factors, it can be trimmed with a knife where necessary. (At 300°F. in the press, this film adhesive bonds the adherends efficiently.)

To prepare the "sandwich" for the press, an aluminum blank (already painted with the primer) is placed on the table with the primed side up. Two metal blanks are inserted in the 14 x 25-inch openings to provide a flush metal surface. The plastic sheet, adhesive film down, is placed on top of the aluminum and centered to the lines scribed on the aluminum (Fig. 6). Now a ½-inch thick felt blanket (Fig. 7) is placed over the whole and the entire "sandwich" is covered with a sheet of cellophane (Fig. 8). This is placed in the press for fifteen minutes (Fig. 9) when the assembly is removed and "broken down." The cellophane and felt blanket are taken off (Fig. 10) and the assembled panels are allowed to stand overnight on skids (Fig. 11). By that time, the bond has developed its strength.

After curing overnight, the assembled panel (Fig. 12) is placed between two metal sheets which act as templates. Holes are drilled through both plastic and aluminum and rivets inserted. This creates an over-all appearance which is in conformity with the rest of the trailer. (It is felt that the bonding would be completely serviceable without the riveting.)

Joining Panel Sections

The assembled skylight panel sections are delivered to the subassembly station at Strick Trailers at their Whitaker and Godfrey Street plant. There the skylight panel sections are joined to other aluminum rough sections of the same length and width and treated exactly as if they were just another piece of aluminum (Fig. 13). On the final trailer product the polyester sheet is on the top, or outside, of the roof (Fig. 14). A complete picture story on the assembly of the skylights follows on the next two pages.

(Plymaster V-2 and Bondmaster M-373 are the adhesive and primer used and are products of the Rubber & Asbestos Co. of Bloomfield, N. J. R & A also took the pictures used in this article and it is through their courtesy that they are printed here.)

SKYLIGHT

FIG. 1—Cleaning aluminum blank

FIG. 2—Brushing on liquid primer

FIG. 3—Cleaning plastic with acetone

FIG. 4—Liquid primer applied to plastic

FIG. 5—Applying film adhesive to plastic

FIG. 6—Plastic sheet placed upon aluminum

FIG. 7—Putting felt blanket in place

ASSEMBLY

FIG. 8—Entire sandwich covered with cellophane

FIG. 9—Sandwich placed in press

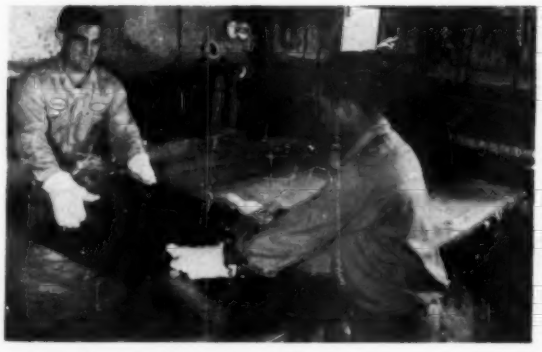

FIG. 10—Removing felt and cellophane

FIG. 11—Assembled panels on skids

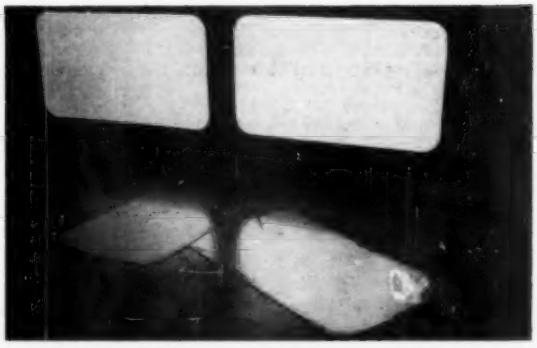

FIG. 12—Assembled panel ready for riveting

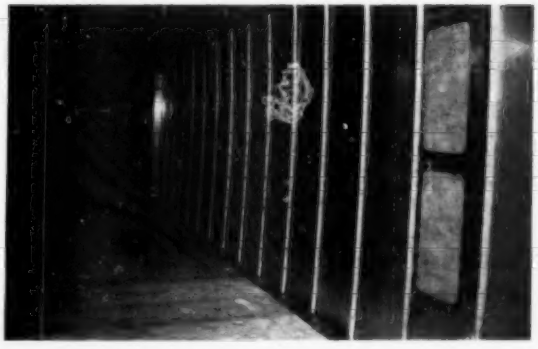

FIG. 13—Panels riveted in place

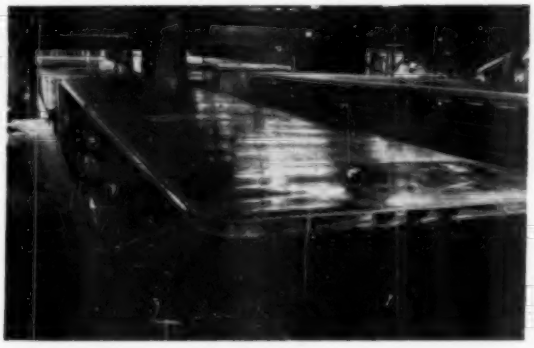

FIG. 14—Plastic sheet on outside of roof

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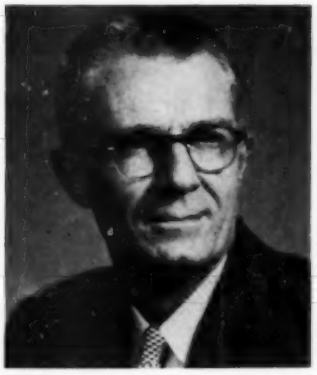

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Automatic Metering Mixing Dispensing of Epoxy Resins

By R. E. CRITCHLOW
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The proper proportioning and mixing of two-part, epoxy compounds is the critical factor governing success in the application of epoxies for use in bonding, sealing, coating, potting and encapsulating. Hand-mixed batches are non-uniform; hand-proportioning is inaccurate; and the amount of labor required for dispensing and mixing is usually high in comparison to the volume of units produced. Material is wasted and rejects are common. Exposure of operators to contact with compound is certainly not desirable.

Some manufacturers are struggling to handle epoxy compounds by hand in applications for which only epoxies are suitable, while others have foregone completely the well-known advantages provided by the superior physical and electrical properties of epoxy compounds, simply because of the difficulty in handling this two-part material. The situation is complicated further by the comparatively short pot-life of most epoxy compounds, which necessitates mixing in small batches.

Need for Automatic Handling

More than five years ago—when Eposet* was first introduced to the brush industry, the H. V. Hardman Co., Inc., began to feel the pressure for a practical, automatic method of handling two-part epoxy compounds. Eposet, an epoxy compound originally designed for setting the bristles in the ferrule in the manufacture of paint brushes, was the first brush setting which provided room temperature curing—completely eliminating the vulcanizing required by the age-old rubber settings used up to that time. The brushmakers quickly recognized the advantages of the new material—particularly the great benefit of room-temperature curing. But they insisted that hand mixing and hand dispensing of this material was impractical, and they realized the advantage which the safety features of an automatic pump would provide.

Although the company had been exclusively rubber and plastics compounders for more than 50 years, the demands of the brush industry alone caused them to seek some means of handling the epoxies automatically.

No such machine existed.

Working to the specifications of their compound, a medium viscosity resin cured with a low viscosity curing agent, they designed and produced the Triplematic* pump to meter, mix, and dispense two-part resins automatically for brush setting. The first fifty machines produced went quickly to the brush industry. The success of the pump spread by word of mouth to other industries using epoxy compounds and since then the machine has been used for virtually every type of industrial application of two-part resins, including epoxies, polyesters, resorcinols and certain polyurethanes. The resin systems handled are filled, unfilled, thixotropic, room temperature, and heated.

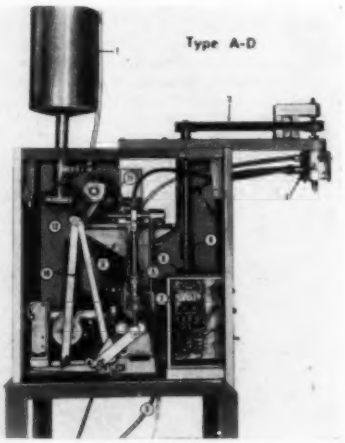


FIG. 1—Pump with side panel removed to show: (1) Resin Hopper; (2) Feed line from Curing Agent Container; (3) Timing Belt Drive; (4) Mixing Chamber; (5) Curing Agent Pump; (6) Flexible Coupling Drive; (7) Agitating Delay Timer; (8) Agitator Motor; (9) Cast Aluminum Frame; (10) Resin Pump and Curing Agent Pump Motor; (11) Resin Pump.

Additional Applications

While the original machine was designed for use in the brush industry, it became evident that the pump ultimately would have an even greater application outside the brush industry requiring a wide variety of resin-to-curing agent ratios and viscosities.

To meet this broader market it was necessary to decide whether to redesign the pump with a broad ratio and viscosity range, which possibly would require an unnecessarily complicated and expensive design, or to

make it a simple design with a comparatively narrow range, yet easily adaptable to ratio and viscosity changes. The second method was decided on because it allowed a simple, low-cost, productive machine with a minimum of moving parts and adjustments, yet which provided complete adaptability to all resin systems.

The Triplematic pump (Fig. 1) consists of a cast aluminum frame that mounts a gear-type resin pump and a piston-type curing agent pump. The pumps are electrically driven by a ¼-hp, 15-volt, 60-cycle electric gear motor. Resin is stored in a steel hopper located on top of the machine and a polyethylene jug containing the curing agent is located below the machine.

An agitator housed in the mixing chamber is driven by a separate ¼-hp motor through a flexible coupling and a timing belt drive. The machine, with its interconnecting tubing, mechanical linkage, and electrical system, is enclosed in a metal cabinet with one removable side panel of expanded metal for cooling.

Simple Adjustments

Because of its extremely simplified, narrow-range design, the pump requires only two adjustments: The ratio adjustment and the volume control. The ratio adjustment is made easily by a supervisor when the machine is first set up. Thereafter a semi-skilled operator can run it, continuously and productively, with a minimum of training and with minimum chance for error, changing the volume of the shot according to production requirements.

Although each model is manufactured with a limited range of viscosities and ratios, conversion kits are available for speedy change-over of any model to handle any other range required. However, virtually all users of the pump have purchased it for a specific production purpose. In almost every case, once the machine was set up, the resin system was never changed.

For example, when one large manufacturer of synchros (small, motor-like position-sensing and regulating devices) converted from a metal-housed to a plastic-housed stator core assembly, he first experimented with various plastic materials and methods of casting. After he had selected a suitable, filled-epoxy system for centrifugal casting, he ordered his machine which was calibrated for the formulation specified. The volume control was easily adjusted at the initial set-up, and the rate of charge was calibrated with the automated line at the time installation was made (Fig. 2). It is doubtful that this manufacturer will ever be concerned with ratios, viscosities, and the volumes other than those presently dispensed by the machine. However, should he ever change materials, or even move the pump to a totally different line for another purpose, it can quickly be changed over to a new resin system with a conversion kit.

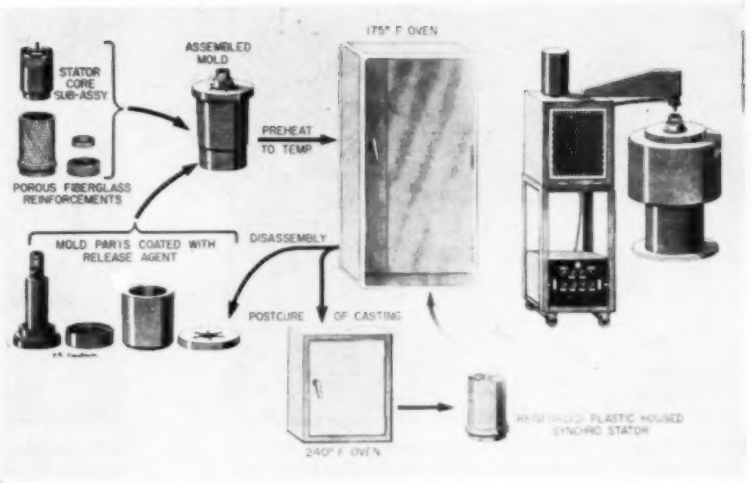


FIG. 2—The pump in automated line for direct dispensing to centrifuge for casting plastic-housed stator core assembly.

In automated installations, the positive cut-off assembly (Fig. 3) assures a sharp cut-off of material after each shot, eliminating all possibility of contaminating the conveyor line between shots. While the positive cut-off assembly was designed primarily for automated installations, it is also widely used on semi-automatic setups, such as setting bristles in paint brush ferrules, (Fig. 4), setting filter cores in steel-end bells (Fig. 5), and setting hammer heads to handles (Fig. 6).

When set up for semi-automatic operation, the pump dispenses a precisely measured shot of mixed material, from 0.3 ml to 24 ml per shot, from one to 72 times per minute at constant speed, regardless of viscosity or volume of shot. In addition to its proven economy and efficiency in handling up to 1400 pounds of material per shift, for volume production of up to 36,000 units per shift, the pump also is paying its way in many shops using less than a gallon of material per day because of the savings in labor for hand mixing and the savings in rejects due to improperly mixed material.

A manufacturer of miniature coils, for example, continues to dispense an epoxy compound consisting of an amine adduct and a silica and slate filled resin by hand, from small paper cups, because 0.4 ml of material must be dispensed slowly to each unit in this unique encapsulating process. Although the machine is obviously capable of delivering this size shot directly, ten such pumps would be required to service his ten casting machines.

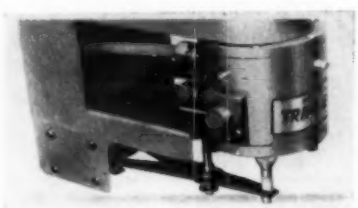


FIG. 3—Close-up of the pump mixing head showing positive cut-off assembly which assures a sharp cut-off of material after each shot.

Total Volume Small

The total volume (21bs. per day) is so small that this manufacturer profits by dispensing material from *one* Triplematic to cups, for as many as ten employees to hand dispense at one time, thus avoiding all loss from rejects which used to occur from improperly mixed or proportioned material.

Perhaps an even more startling example of the need for machine mixing, in unsually small production, is the case of a wire and cable manufacturer with widely fluctuating sea-

FIG. 4—Pump set up for automatic metering, mixing, and dispensing epoxies for setting bristles in ferrules of paint brushes

FIG. 5—Pump set up for automatic metering, mixing, and dispensing Eposet for bonding steel-end bells to monel wire-cloth.

sonal production. He uses his machine for sealing connectors on insulated cable.

During peak production his load is so great that two machines are required to maintain schedules. During the slow periods, however, use of even one machine is totally unjustifiable by all management standards, save one: *quality control.* Although it would be actually more convenient to hand mix and dispense the small amount of material needed during this period, this manufacturer, too, has found that rejects due to improperly sealed connectors precludes any possibility of hand mixing.

Summary

An automatic, resin metering, mixing, and dispensing system offers a number of advantages: it lends itself to fully-automated production, when desirable; it can be operated by unskilled personnel for semi-automatic operation; it can be used strictly for metering and mixing in conjunction with hand-dispensing or other types of dispenser where desirable; it provides a uniformity and quality from one charge to the next which is unattainable by hand mixing; it reduces the amount of resin wasted; it immediately delivers precisely the amount of resin required, and cut-off with no drip, it reduces expensive rejects. Last, but not least, it provides a *safer* way to handle certain curing agents and resins than hand mixing.

*Eposet and Triplematic are trade names of the H. V. Hardman Co., Inc. The pictures printed here are also through the courtesy of H. V. Hardman Co., Inc.

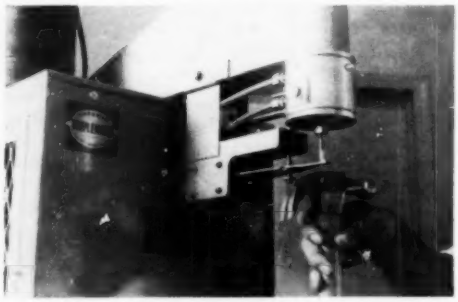


FIG. 6—The Triplematic pump set up for automatic metering, mixing, and dispensing epoxies for setting steel hammer head to wood handle.

About the Author . . .

R. E. CRITCHLOW has headed the sales and development program of the Triplematic Pump Division since 1955. He has an extensive background in the sales and development of material and equipment for the chemical and plastics industry, and is an active member of the Society of Plastics Engineers committee for processing machinery.

From pilot plant to FULL PRODUCTION

Laboratory Mixing Solves Adhesive Production Problems

When compounding a wide variety of molding materials in a commercial research laboratory, one aim is to meet the user's specific needs. Another is to duplicate results of each formulation on a much broader scale in regular plant production, once a sample is accepted by the user.

Williamson Adhesives Inc., Skokie, Illinois, formulates many special pre-mix molding compounds for special end uses. They daily faced a transition from the laboratory to the production line, and recently solved this problem with a large production floor mixer—scaled up physically and operationally to duplicate the exact results of a tiny laboratory mixer. As a result, production line formulation modifications are no longer required, production is both much faster and more versatile, company officials state.

At Williamson, the practice is to develop custom samples of polyester pre-mix compounds and make test runs of these in the 2¼-gallon laboratory mixer, for user tests. Quantity production usually is held up until after the formulation is determined successful by the user's own tests. This means that after the tests production quantities of the formulation must be exactly the same as the sample approved.

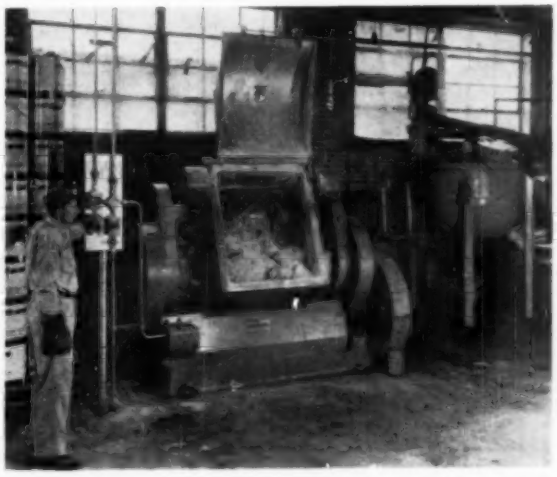
Formerly, to duplicate laboratory operations on a production scale, it was necessary to make extensive modifications of both the formulation and the manufacturing procedure. Such factors as optimum batch size, rate of addition of raw materials, heat buildup, loss of volatiles, fiber degradation, and complete production cycle time were determined by actual production trials. This process was both expensive and time consuming. In addition, the most rigid control specifications were needed to produce consistently uniform material.

This is no longer true today. Since the 100-gallon production mixer faithfully duplicates the action of the laboratory mixer, production time has been reduced by 50 per cent. Laboratory formulas may be directly scaled-up to production size, with the assurance that the finished product will be a duplicate of that produced on the laboratory machine.

Key to the new mixing setup at Williamson lies in the basic design of the equipment itself. According to company chemists, Baker Perkins' Chemical Machinery Division engineers, who designed the laboratory unit, scaled the larger counterpart to be identical in action. Both units employ special spiral blades which develop a combination kneading, coating and stretching action to mix ingredients rapidly into the consistency needed.

Both Baker Perkins mixers are capable of handling loads of widely dissimilar materials, (plastics, heavy viscous semi-liquids or dense fibrous masses). Therefore, compounding in the small mixer is considerably flexible, and the follow-through is identical with loads as high as 500 pounds in the 50-hp production unit.

"King-pin" at Williamson Adhesives in Skokie, Ill., is this 2¼-gallon Baker Perkins laboratory mixer used in developing custom samples of polyester pre-mix compounds for user tests. The unit sets the "pace" for a 100-gallon production floor mixer.



Scaled up physically and operationally by Baker Perkins engineers to duplicate exact results of a tiny laboratory mixer, this production mixer at Williamson Adhesives handles loads as high as 500 pounds. Production time is reduced 50 per cent.

BONDING

Magnesium To Expanded Polystyrene Foam

User-supplier liaison cuts adhesive costs up to 94%

J. F. WOLFE
Specialist, Methods Department
General Electric Co.
Pittsfield, Massachusetts

and

BERNARD P. ALDEN
Technical Service Representative
Rubber & Asbestos Corp.
Bloomfield, New Jersey

The Problem

"We require a radar shelter consisting of a horizontal cylinder 20 feet in diameter and 20 feet long, rotatable through 340 degrees. This cylinder will be cut off approximately 7 feet below the horizontal center to form a rectangular mounting base.

"This shelter shall operate under the following conditions: 50 mph wind from —40°F. to 125°F., as well as a 7 pounds per square foot ice load; and shall be capable of withstanding a maximum of a 125 mph wind from —65°F. to 130°F. The shelter shall have a U factor of at least .065 inch."

These were the problems presented to design and manufacturing engineering personnel at the Missile & Ordnance Systems Department of the General Electric Company, at Pittsfield, Mass. The story of how they solved them successfuly epitomizes alert engineering and developmental work with the most modern of metals, plastics, and adhesive-bonding techniques . . . and represents, in addition, an excellent example of how close coordination and interchange of information between the adhesive supplier and the user can bring about added economies and efficiencies in production.

The design engineering group at Pittsfield specified the materials to be used: expanded polystyrene foam (Dow's Styrofoam) and magnesium. It was determined that the basic construction which would enable them to meet the stringent specifications would involve sandwich panels consisting of magnesium as the face material, which in turn is adhesive-bonded to the Styrofoam core.

Why Magnesium Skins?

Since the skins, or facings of a sandwich provide the necessary rigidity to a panel and, in addition, must carry the major loads, they must possess high compressive and tensile strength. Most of the structural properties and a great deal of the durability of a panel, therefore, is primarily determined by the material used for the skins.

For G-E, magnesium was the logical choice. It is light enough in weight so that even heavy gauge sheeting would still answer their end-use requirements since, under conditions of equal rigidity, magnesium can generally be expected to be 25% or more lighter than other metals. It is durable, non-rusting, and requires no extensive maintenance once assembled.

Why Styrofoam Cores?

The choice of Styrofoam as the core material, too, was a logical one since its low density (its weight is only 2.4 ounces per board foot) and its high compressive strength (3,000 pounds per square foot), provided the rigidity and durability that were needed. Beyond that, however, Styrofoam retains its original average insulating value, K = BTU/in./sq. ft./hr./°F., permanently because of its inherent water resistance.

Since the entire assembly had to maintain a U factor of .065 for this application, the engineers specified 5 inches of 2-pound density Styrofoam between .064 inch thick magnesium sheets—an assembly that easily met the necessary thermal insulation requirements.

Why Adhesive Bonding?

The basic problem was that of the actual production of a sandwich assembly made up of these completely different types of components. The manufacture of such a panel, consisting of magnesium faces and a Styrofoam core, represents a classic illustration of all the advantages of the use of chemical fastening methods made possible through the use of modern industrial adhesive formulations. (See next page).

While it was immediately apparent that adhesive bonding offered the most economical as well as the most efficient solution to G-E's fabrication problems, selection of the specific adhesive was not quite as simple. Since there are almost as many different types of chemical fasteners to choose from as there are different face and core materials, the determination of the specic adhesive formulations best suited to the manufacture of these radar shelters presented an interesting problem in cost and production analysis to the methods development specialists of the company.

Many solvent-type adhesives will attack or dissolve Styrofoam. Some require an extensive drying time after the adhesive is spread and before the panel can be assembled so that entrapped solvent will not weaken the adhesive bond.

Still others of the solvent-type formulations cannot withstand the heat build-up of 140°F. or they become thermoplastic at these temperatures and cannot hold the magnesium firmly as it expands and contracts. At the other end of the temperature scale, such formulations can usually be expected to become too brittle in the below-zero ranges and tend toward cracking or shattering under shock or impact.

Since the effective adhesives for this application had to meet all the requirements of the G-E specifications and, in addition, had to lend themselves to economical production techniques, G-E embarked upon an extensive evaluation program of the available adhesive for magnesium and Styrofoam listed by the materials suppliers.

Testing The Adhesive

Test samples of magnesium sheets with 5-inch thick Styrofoam cores, measuring 2¾ inches wide by 4½ inches long, were produced and checked for strength at 72°F., 140°F., and −65°F., as shown in the accompanying sketch.

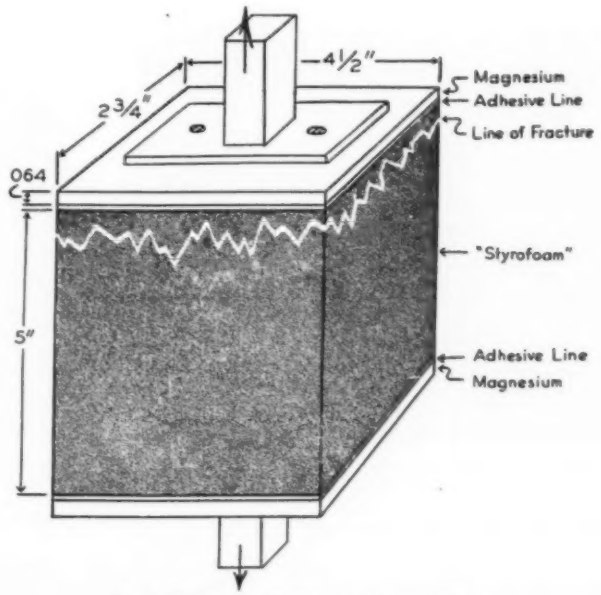
Extensive testing to destruction finally narrowed down the choice to a single 100%-reactive, solvent-free modified epoxy formulation[1] and special hardener[2] expressly developed for Styrofoam bonding. Samples bonded with this formulation failed in tension in the Styrofoam at approximately 25 pounds per square foot load at all three temperature levels tested, indicating that the bond between the magnesium and the Styrofoam was stronger than the cohesive strength of the Styrofoam itself.

This formulation, however, was priced in the vicinity of $37.00 per gallon due to its high specific gravity of 17 pounds per gallon (epoxy formulations are sold by the pound) and while initial production was instituted on this basis, it was at this point that the technical representatives of the adhesive manufacturer were called in for consultation in an effort to determine whether the unit was being over-designed or whether other adjustments in technique could be made to permit the use of lower-cost bonding agents.

It is indicative of modern adhesives marketing that subsequent cooperative evaluation work on the part of the adhesives manufacturer and the user ultimately replaced the original material with two other formulations: one a specially modified epoxy (with thixotropic additive incorporated to minimize flow) selling at less than $25.00 a gallon (a savings of 32½%); the other, a reclaimed rubber adhesive (incorporating a specially formulated solvent blend to eliminate attack on the Styrofoam cells) priced at less than $2.00 a gallon in the quantities involved! For some of the assembly, then, this interchange of technical assistance resulted in immediate raw material cost savings of up to 94%.

Preparation of Sandwich

The only preparation for the magnesium sheets is a chromic acid treatment on both sides of the faces to insure maximum cleanliness and greatest adhesion. The Styrofoam is shipped to G-E in boards 12 inches to 18 inches wide by 108 inches long, from 1 inch to 5 inches thick. These foam boards are then cut to the proper lengths, edge-coated with adhesive, and clamped together with



Schematic Sketch of Test Sample Arrangement

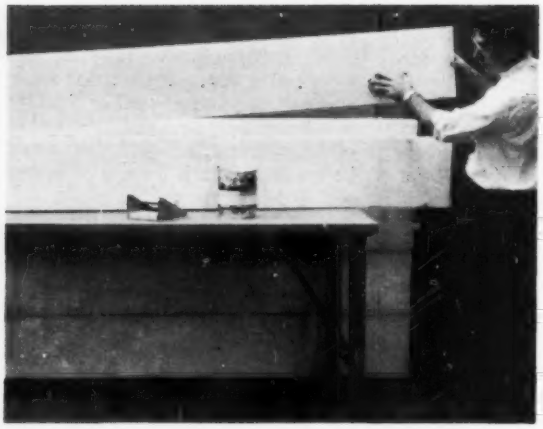


FIG. 1—Styrofoam boards, 12 inches to 18 inches wide by 108 inches long, from 1 inch to 5 inches thick, are edge-bonded to produce panel widths from 25 inches to 48 inches wide.

FIG. 2—After the edges of the Styrofoam planks have been coated with epoxy adhesive and butted together, they are clamped to maintain proper alignment until the adhesive "sets."

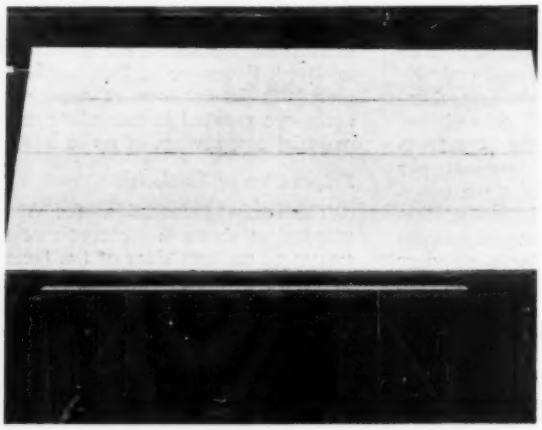


FIG. 3—The edge-bonded planks of expanded polystyrene have now been formed into completed "rafts."

FIG. 4—The "rafts" are cut to desired dimensions and configurations with conventional band saw.

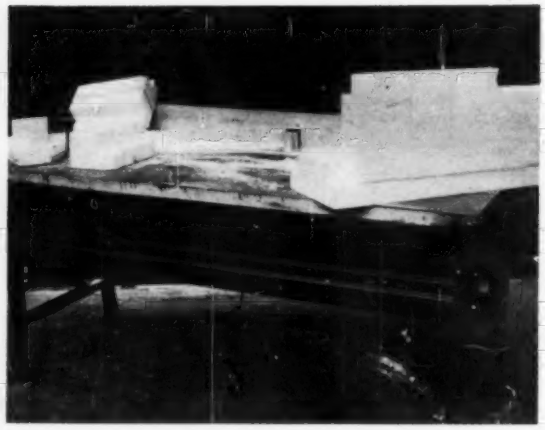


FIG. 5—Here the "rafts" are being cut to necessary configurations prior to being faced with magnesium sheets.

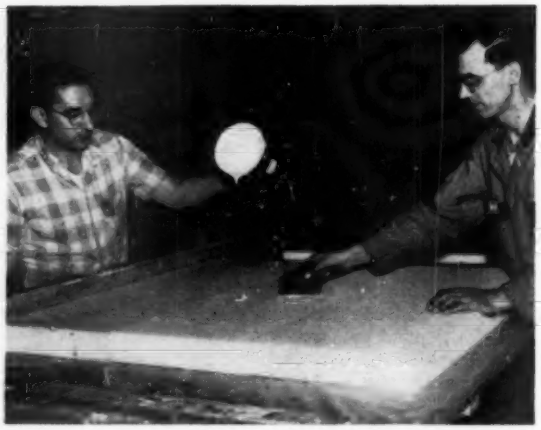


FIG. 6—The edge-bonded planks are coated on exterior surface with reactive epoxy-based paste adhesive.

STEP-BY-STEP: Bonding

FIG. 7—In the next step, the exterior magnesium skin is laid on the adhesive-coated expanded polystyrene panel.

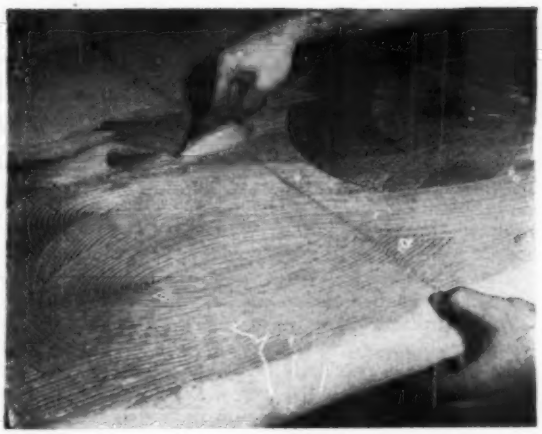


FIG. 8—An inexpensive reclaimed rubber resin adhesive is trowelled on interior surface of panel.

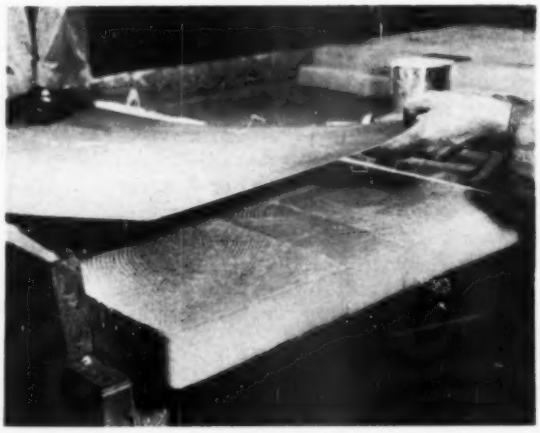


FIG. 9—Magnesium skin is placed on the interior adhesive-coated surface of the Styrofoam panel.

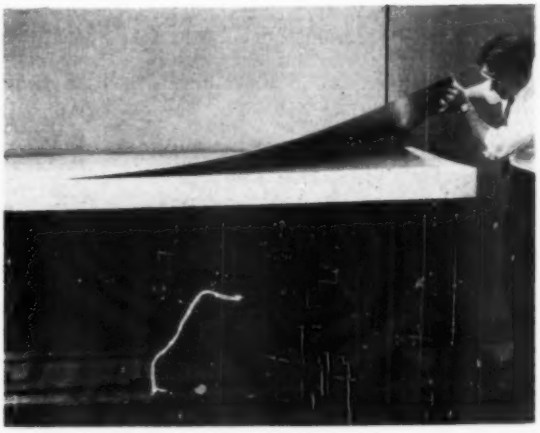


FIG. 10—Another view of the magnesium skin as it is affixed to the expanded polystyrene panel.

FIG. 11—Over-all view of magnesium-faced bonded and bevelled panels ready for assembly.

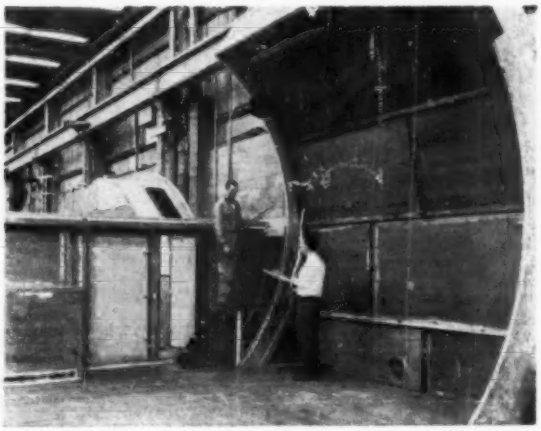


FIG. 12—Over-all view of partially assembled radome section with panels in place.

Magnesium to Expanded Polystyrene

standard cabinet maker's clamps to achieve the necessary panel widths from 25 inches to 48 inches wide. Such assemblies of the Styrofoam boards, called "rafts", are frequently as large as 48 inches wide by 96 inches long by 5 inches thick for some of the panels involved.

During the initial application of adhesive to bond the Styrofoam boards together, and throughout the clamping and room temperature drying, the boards remain on specially constructed pallets on a roller conveyor (at work station height), thereby assuring maximum flexibility and portability in moving pallets to the routing and sawyer areas up to the section assembly areas.

Subsequent to the bonding of the foam planks to themselves, the bonded "raft" is cut with an ordinary band saw to the desired shape and size by using the previously patterned magnesium sheet as a template for cutting. The tolerances in dimension in cutting the rafts to size is ±.030 inch.

The shaped foam is then put on the movable pallets along with the inner and outer sheets of magnesium which will make up the faces of the sandwiches. These pallets are constructed with a rear and two sided straightedges plus slots at various points for edge-clamping to accommodate all sizes of panels.

Bonding the Faces and Cores

Further investigation of the bonding problems and a re-analysis of the requirements of the end-use service conditions on the part of the methods development specialists of G-E and the technical service people of the adhesive manufacturer established the fact that the interior of the radar shelter, because of the high insulating factors of the components, could utilize an adhesive which would exhibit the necessary high strength but within a greatly restricted temperature range. This, it was felt, would permit the substitution of other families of adhesives in place of the more costly epoxy formulations whose superior strength under temperature extremes represented adhesive *over-designing* as far as the interiors were concerned.

The problem of attack on the Styrofoam with solvent-dispersed adhesives still remained, however, and it was purely coincidental that this radar shelter project coincided with the development by the manufacturer of a series of reclaimed rubber-resin formulations specifically for the bonding of Styrofoam without fear of cell attack. The new mastic adhesive which was adopted after rigorous testing,[3] incorporates a specially formulated solvent blend which does not collapse the cells of rigid foamed polystyrene. Accordingly, this easily-spreadable solvent-dispersed rubber material, in a price range below $2.00 a gallon in production quantities, was substituted for the $37.00 a gallon material formerly used to bond the magnesium skins to the Styrofoam cores making up the interior of the shelters.

After the neutral-colored mastic is spread on the Styrofoam with a conventional trowel, the raft is flipped over and positioned on the magnesium sheet which will form the shelter's interior walls. This leaves the second side of the foam core exposed for application of the more heat- and cold-resistant epoxy formulation.

For the exterior skin, too, various savings in raw materials, time, and labor were effected as a result of this close coordination of efforts between supplier and user.

In place of the more flowable material originally used in production, the adhesive manufacturer supplied a modified epoxy formulation,[4] which incorporates a thixotropic, non-sag additive. This made for smoother trowelling of the adhesive on the Styrofoam and, in addition, made it easier to control the adhesive placement, thus eliminating overflow and drip on the sides of the core and the accompanying labor involved in removing such overflow.

In addition to the formulated epoxy component, a special red-dyed chemical hardener was provided to permit swift visual check of the thorough mixing of the two components.

Prior to the start of the assembly

Twelve well-established generic advantages of adhesive bonding as a joining technique:

- **Adhesives permit the distribution of stresses over the entire joining area, thereby eliminating local stress concentration.**
- **Adhesives permit the use of lighter gauge materials to produce the same strength and rigidity, thus saving weight and cost.**
- **Adhesives provide continuous contact between mating surfaces, thus allowing bonding and sealing in one operation.**
- **Adhesives, in themselves, offer a measure of thermal insulation.**
- **Adhesives provide water resistance and avoid water entrapment, thus inhibiting corrosion.**
- **Adhesives permit smooth contours in the finished assembly without requiring extra finishing operations.**
- **Adhesives eliminate gaps and bulges as well as any external projections which tend to be present when mechanical fasteners are used.**
- **Adhesives eliminate the need for drilling holes and thereby preserve the unbroken protective surface of the metal faces of the sandwich.**
- **Adhesives increase the fatigue life of a bonded part.**
- **Adhesives permit thin sheets of material to be mated without distortion.**
- **Adhesives enable the user to bond at ambient temperatures, thus eliminating all the high heat dangers normally involved when welding or brazing light metals such as magnesium.**
- **Adhesives usually involve less specialized (and therefore less costly) personnel for the application than are demanded by other fastening methods.**

operation, the epoxy resin and hardener are pre-weighed and pre-packed in separate containers. At the stage of production where the outer magnesium skin is to be affixed to the outer Styrofoam core, the assembly group thoroughly mixes resin and hardener, using the striations caused by the red dye as a guide to complete homogeneity of the mix.

The mixed material is then trowelled to the outer surface of the Styrofoam with disposable Masonite spreaders. The second sheet of magnesium is then positioned, the foam-to-magnesium relationship being automatically maintained because of the construction of the pallets.

The panel assembly is then clamped in place and loaded with sandbags weighing 25 pounds each. Both the reclaimed rubber and the epoxy adhesives cure at room temperature and in neither case is external pressure necessary to effect the bond. The use of sandbags is purely to insure intimate contact of the adhesive-coated surfaces on the various faces of the assembly. At room temperature, the bonded assembly can be handled in 4 to 6 hours after mating and it develops 85% of maximum strength in from 14 to 24 hours.

Vendor Consultation

The efficiencies and economies in production which are discussed in this article came about as a result of an intensive Value Analysis Study devoted to this specific radome project. While the cost savings resulting from the free exchange of information between supplier and user reached unusual levels in this instance, G-E has a background of promoting such cooperative effort between its vendors and the methods development specialists of its plants.

Section of radome assembly, edge-grooved to accept tongued mated section.

An entire program of Value Analysis "Seminars" is devoted to arranging for meetings between G-E's vendors and its local plant design, engineering, and production personnel throughout the country. One of the basic purposes of these meetings is to pave the way for extensive dissemination of technical data whether or not related to specific, immediate production, or design problems.

With regard to general industrial usage of adhesives, this particular case history dramatically verifies the fundamental concepts underlying proper adhesive selection so frequently stated by manufacturers in that industry:

There are but *two* basic considerations in industrial adhesive selection:

- **What are the desired properties of the adhesive required to do the job?**
- **What method of application is most suitable?**

Detailed information on the end-use properties of the completed assembly must be provided to the supplier. Where the ultimate service conditions of the completed assembly are the determining factors of adhesive selection, that aspect must be carefully investigated and thoroughly detailed. It is not sufficiently informative to request "high strength," particularly when savings of up to 94% in basic material costs can be enjoyed as a result of complete consultation and cooperation with the vendor.

1—"Bondmaster M664"; 2—"CH-15"; 3—"Bondmaster C458," and 4—"Bondmaster M688," all products of the Rubber & Asbestos Corp., Bloomfield, N.J.

About the Authors . . .

Bernard P. Alden

J. F. Wolfe

BERNARD P. ALDEN was born and bred in the Boston, Mass., area and is now New England technical service representative for the Rubber & Asbestos Corp. with headquarters in Waltham, Mass. Mr. Alden has twelve years' experience in industrial adhesives sales and service.

J. F. WOLFE has been with the General Electric Co. since 1947. His responsibilities include initiation, investigation, development and application of new and improved methods and processes. He is now a methods engineer with the Methods and Planning—Assembly Unit.

The Case of the FLYING ADHESIVE

America's first and the fastest prop-jet airliner, the Lockheed Electra now in production at Burbank, Calif., utilizes a plastic adhesive for bonding metal to metal that is stronger than the metal itself.

According to B. F. Goodrich Industrial Products Company, maker of the "Plastilock" adhesive, wing and tail assemblies, interior panels and other structural parts of the Electra are being locked together in a bond that reduces weight and is more permanent and durable than any other method of attachment.

The Electra, designed to carry up to 98 passengers, has a maximum gross take-off weight of 116,000 pounds. The huge aircraft is 104½-feet long, 32 feet high to tip of tail, with a wing span of 99 feet. A Navy version of the Electra will carry a crew of 10 and be equipped with the latest instrumentation for detection of enemy subs.

The semi-elastic bond created by the Plastilock adhesive absorbs the uneven expansion that develops between unlike materials, Goodrich adhesives engineers pointed out. Tests conducted by Lockheed prior to adoption of the plastic adhesive showed that adhesive strength greater than 4,000 pounds per square inch can be achieved in metal to metal bonds.

Plastilock adhesive tape being applied to interior panel for installation in the Electra.

The metal parts being bonded in the Electra are subjected to a temperature of 350 degrees under a pressure of 100 pounds per square inch to attain the bonding properties desired.

The B. F. Goodrich adhesive, identified as Plastilock 638, is supplied in the form of tape. When applied and cured under heat and pressure, it has a standard sheer strength at room temperature of 4,000 pounds per square inch according to B. F. Goodrich engineers.

Waterproof Thermosetting Adhesive From Tree Bark

"Silvichemists" from the Olympic Research Division of Rayonier, Inc., Shelton, Washington, have reported a new silvichemical from tree bark which successfully yields a low-cost, weatherproof, thermosetting adhesive for plywood. This new bark extract, designated as "HT-120," has proved to be a successful intermediate agent in the formulation of a plywood bonding agent, according to F. W. Herrick and L. H. Bock, silvichemists. They said the resulting adhesive meets "all present commercial requirements" for exterior type plywood.

HT-120 is chemically extracted from the bark of the western hemlock. When it is combined with polymethylolphenol with a high proportion of reactive methylol groups, a bonding agent is formed substantially reducing the expensive phenol normally required in plywood adhesives for outdoor uses.

The scientists' report revealed that during the hot press operation, the polymethylolphenol reagent acts as a crosslinking and co-polymerization agent for the bark extract. The result is a weatherproof wood bond which has been extensively tested in Douglas fir plywood. They stated further that coniferous tree barks yield highly valuable intermediates which have many resin applications.

The new adhesive based on HT-120 can be produced in a dry form or as a 40 to 45 per cent solids solution that is quite stable at ordinary temperature. This thermosetting adhesive is fast curing and within the range for commercial acceptance for exterior plywood. The adhesive formulation calls for 49 per cent bark extract, 34 per cent polymethylolphenol and 17 per cent filler on a solids basis.

For the chemical cellulose producer, the immediate effect is a still more complete utilization of bark wastes for additional commercial uses. For the plywood industry, the report indicates, new savings in adhesive costs are possible as well as broader marketing applications offered by a completely weatherproof bonding agent.

The conservation gains inherent in a fuller consumption of the entire tree through the new science of silvichemistry are called "immeasurable," while the future for such tree chemicals has been described as "prodigious." The words "Silvichemical" and "Silvichemistry" were coined a few years ago by the Research Division of Rayonier. They mean "tree" or "woods" chemistry.

Disk Shear Test for Adhesives

By S. B. TWISS and L. B. CLOUGHERTY
Chrysler Corporation, Detroit 31, Michigan

The increasing use of adhesives in structural applications has focused considerable interest on methods of determining strength properties of adhesives in metal-to-metal bonding. One of the most important of these properties is shear strength. There are two ASTM methods for measuring adhesive shear strength: a lap shear test, Tentative Method D-1002-53T, "Strength Properties of Adhesives in Shear by Tension Loading (Metal-to-Metal)"[1], and a block shear test, Method D-905-49, "Strength Properties of Adhesives in Shear by Compression Loading."[2]

The widely used lap shear test has much to recommend it. Among its advantages are precision, simplicity and widespread use. It is not, however, an accurate measure of adhesive shear strength. The direction in which the separating force is applied causes a combination of shear and peeling stresses, due to eccentricity of loading, so that the strength measured is not the actual adhesive shear strength. This eccentricity of loading is increased as the shear strength increases. A description of this effect is clearly outlined by DeBruyne and Houwink.[3]

The block shear test, ASTM Method D-905-49, is specific for wood adhesives. In this test, two overlap bonded blocks are sheared by compression loading. The ram used for loading has a universal swivel to compensate for misalignment of the specimen. A modification of this test in our laboratory, using metal specimens, resulted in low apparent shear strength and a very low order of reproducibility. This was attributed to misalignment of the specimens. In order to obtain a more accurate measure of adhesive shear strength conveniently, a new test method was designed. This test consists of shearing a disk from a rectangular strip by compression loading. The specimen can rotate slightly in the test fixture and, therefore, is self-aligning. Peeling stresses are minimized by maintaining a very small clearance between the specimen and the shearing tool. This arrangement does not cause the specimen to bind in the fixture. The use of thick sections for the adherends also reduces peel forces. In addition, the circular shape of the bonded area may achieve a more uniform distribution of stresses than is obtainable in the lap shear test.

Test Apparatus

Photographs of the disk shear test fixture, assembled and disassembled, are shown in Figures 1 and 2. The semi-circular anvil was made of hardened steel to prevent deformation during loading. The anvil was bolted to the spacer for increased rigidity. One of the aluminum frames was machined to contain a heater and a thermostat. The heater selected was a "Chromalox" disk element, 115v-400w, Type HSP-31. The thermostat used was a Fenwal "Thermoswitch", 5 amp, 115v AC, 0-600°F. range, Catalog No. 17002-0. A pilot light was inserted in the heater circuit. No insulation was required, since the temperature variation proved to be only ± 2°F. at a thermostat setting of 400°F.

FIG. 1—Disk Shear Fixture, Assembled.

The specimens consisted of disks and strips of the desired metals. The strips were rectangular pieces 1.125 by 4.250 by 0.250 inches thick. The disks were 1.125 inches in diameter and 0.250 inch thick. A hole 0.09 inch in diameter was

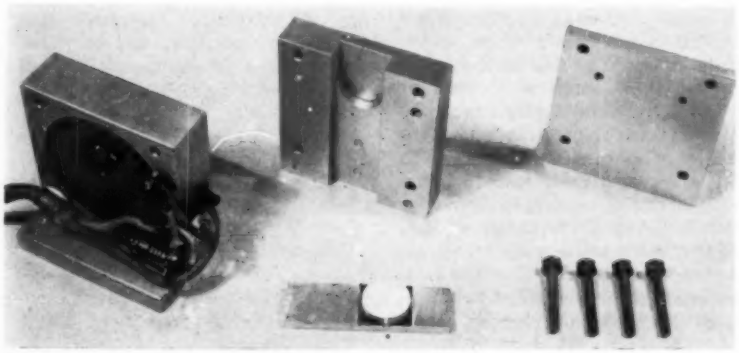


FIG. 2—Disk Shear Fixture, Disassembled.

Note: This paper was presented in part before a meeting of Committee D-14 of the American Society for Testing Materials, Philadelphia, Penna., October 31, 1957, and is also appearing in the September, 1958, issue of the ASTM Bulletin.

drilled from the edge of the disk to the center for insertion of a thermocouple to determine specimen temperature for elevated temperature testing.

In order to evaluate the disk shear test, it was decided to compare it directly with the lap shear test (ASTM Method D-1002-53T).[1] This comparison was designed to include average strengths obtained and precision of the two tests, both at room temperature and at elevated temperatures. Groups of 20 to 50 specimens were tested so that a statistical analysis of lap shear *versus* disk shear results could be made. In addition, studies of the effect of loading rate in the disk shear test and the effect of etching of steel on the shear strength of H2S cement were included.

A series of specimens was planned to include two metal adherends, aluminum and steel, with two different adhesives. AA 2017 aluminum was used for the disk shear specimens and Alclad AA 2024-T3 panels (6.375 by 3 by 0.064 in.) were used for lap shear specimens. Cold-rolled, plain carbon steel (SAE 1010) was used for both disk and lap shear specimens. Two adhesives were selected: Cycleweld C-14 and Cycleweld H2S. The former is a modified epoxy type liquid adhesive which can be cured at ambient temperatures and contact pressure. It has the high shear strength and low peel strength typical of epoxy adhesives. Cycleweld H2S adhesive is a rubber-resin type adhesive of spray viscosity, requiring considerable heat and pressure to effect a cure. It has a solids content of 26 ± 2% and a viscosity of 3500 ± 200 cps at 80°F. Viscosity increases slowly on aging. The H2S adhesive was checked against these specifications before use. This adhesive has relatively lower shear strength and higher peel strength than the epoxy type.

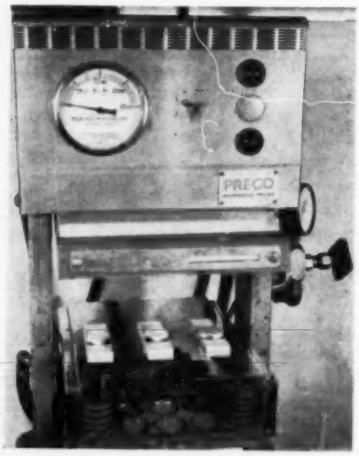


FIG. 3—Bonding Jig in Heater Press.

Experimental

Metal Preparation. The disk shear adherends, both aluminum and steel, were surface ground to 0.250 inch, sanded with 180 grit aluminum oxide cloth, and cleaned with hot trichloroethylene. This completed the surface preparation of the steel pieces for C-14 bonding and for H2S bonding without etching. To obtain optimum strengths with H2S adhesive, the steel pieces were etched with a 10 per cent sulfuric acid solution at 122°F. After a 5-minute immersion, the surfaces were washed with distilled water and wiped dry. The aluminum disks and strips were given a chromic acid etch as a final surface preparation. The etching bath used was a solution containing the following in parts by weight: potassium dichromate 11.1, sulfuric acid 100, and water 340.[4] The aluminum was held in the bath 10 minutes at 155-160°F. A water rinse and thorough drying completed the surface preparation.

The steel panels for lap shear specimens were sanded with 180 grit aluminum oxide cloth and cleaned with hot trichloroethylene. Panels for H2S specimens only were then etched the same as the H2S disk shear specimens. The aluminum panels were cleaned with hot trichloroethylene and etched with chromic acid solution, in a similar fashion to the disk shear specimens.

Bonding Procedures

In preparing the C-14 disk shear specimens, the C-14-A (resin) and C-14-B (hardener) were mixed according to the manufacturer's directions and applied to the disk and the center portion of the strip. When the adhesive became quite tacky, the disks were centered on the strips. Masking tape shims were used to maintain the desired glue line thickness. A light weight was applied to keep the adherends in place. The adhesive curing cycle was 16 hours at ambient temperature, followed by 40 minutes at 185°F. After cooling, the specimens were ready for testing as shown in Figure 2. The C-14 adhesive lap shear specimens were prepared in a similar manner, using 6-inch wide panels and 0.500-inch overlap. After curing, all panels were sawed into strips one inch wide for testing.

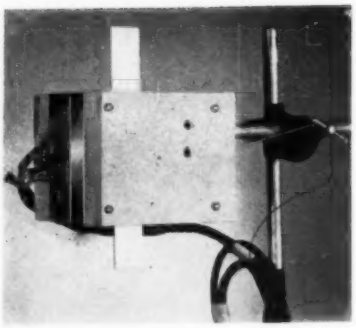


FIG. 4—Lap Shear Heater—Closed.

For the H2S adhesive disk shear specimens, the cement was applied to both the disks and the center sections of the strips and leveled with a spatula. Shims of masking tape were used to produce wet film thicknesses of 0.020 or 0.013 inches, depending on the final bond thickness desired. The adhesive was air dried for 1 hour and precured 25 minutes at 180°F. The disks were then centered on the strips and cured for 30 minutes at 200 psi and 365°F. A Preco hydraulic laboratory press supplied the heat and pressure for bonding. The press platens were electrically heated. A spring-loaded bonding jig was used to control the bonding pressure, as shown in Figure 3.

The jig consisted of two steel plates (7 x 8 in.) separated by calibrated springs. Accurately-machined side spacers retained the upper plate and allowed it to move as the press was closed. By selection of springs with the proper rate, any desired loading could be obtained. The jig was heated by the press platens; specimens to be bonded were inserted between the upper press platen and the upper plate of the bonding jig. Normally, three disk shear specimens were lined up across the center of the upper plate, the press closed immediately, and the specimens maintained under a uniform pressure of 200 psi for 30 minutes. H2S adhesive lap shear specimens were bonded with a 0.500-inch overlap, using the same bonding arrangement, pressure and temperature as for the disk shear specimens.

Testing Procedure

A Tinius Olsen Lo-Cap universal testing machine was used for all shear strength tests. A loading rate of 0.05 in./min. was used through-

out the testing, except in cases where loading rate was being studied. Disk shear specimens were loaded in compression, using the disk shear fixture. For elevated temperature tests, the fixture was heated to the desired temperature and the specimen placed in the fixture. After ten minutes in the heated fixture, the load was applied. A thermocouple inserted in the disk recorded the temperature. Specimens reached test temperature in about 2 to 3 minutes. Lap shear specimens were tested in tension, using standard Templin jaws. For elevated temperature tests, a compact, insulated, thermostatically-controlled heater was used.

Figures 4 and 5 illustrate two views of the lap shear test heater. Two aluminum blocks hinged together formed the body of the fixture. One block had a Thermoswitch inserted in a hole drilled into the center of the block, and a Chromalox heater bolted to its outer face. Slots were cut in the inner face of each aluminum block to accommodate the test specimen and hold it in contact with the heated block. A spring-loaded aluminum button containing a thermocouple was mounted at the back of the slot in the unheated block and opposite the specimen overlap. This arrangement gave positive contact between the thermocouple and specimen when the heater was closed.

The back faces of both aluminum blocks were covered with Transite to provide insulation for improved temperature control. The heater was held closed by a magnetized iron button embedded in the inner face of one block and facing an iron button embedded in the other block. A rod threaded into the heated block permitted the heater to be mounted on a ring stand, which could be set on the base of the universal testing machine. Silicone grease was smeared on the test strip to give good contact with the heated aluminum block and thermocouple carrier. The specimen was inserted, the heater closed and the two ends of the specimen clamped in the Templin jaws. The preheated fixture brought the lap shear specimen to temperature within two minutes. Temperature variation was $\pm 2°F$. Specimens were kept in the heater 10 minutes prior to testing at the elevated temperatures.

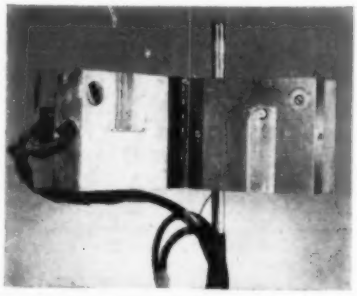


FIG. 5—Lap Shear Heater—Open.

Table I—Comparison of Disk Shear and Lap Shear Test Results at Room Temperature

		Lap Shear Tests			Disk Shear Tests		
Adhesive	Adherend	Shear Strength, Psi	Std. Dev. (σ), Psi	No. of Specimens	Shear Strength, Psi	Std. Dev. (σ), Psi	No. of Specimens
C-14	Aluminum	3371	384*	51	5848	442*	48
C-14	Steel	2824	159	24	5182	429*	50
H2S	Aluminum	2236	188	24	3360	187	20
H2S	Steel**	2466	166	24	3232	238	20

*Results obtained in June, 1956. All other tests were made in June, 1957. **Steel etched with dilute sulfuric acid.

Results and Discussion

The series of tests comparing bond strengths included aluminum to aluminum and steel to steel disk shear specimens bonded with each adhesive. The same four combinations of adhesives and adherends were tested in the lap shear test. It should be noted that, in the case of the steel specimens bonded with C-14 adhesive, the steel was not etched. However, for steel specimens bonded with H2S adhesive, optimum results were obtained with steel etched with dilute sulfuric acid. The average shear strengths at room temperature, standard deviation and number of specimens tested are listed in Table I.

It is evident from this table that the disk shear test gives substantially higher values than the lap shear test. The disk shear results using C-14 adhesive are 73 per cent higher on aluminum and 83 per cent higher on steel than the comparable lap shear test. This is precisely the effect to be expected if peeling stresses were effectively reduced. In the case of the H2S adhesive which has good peel strength and lower shear strength, the difference of 44 per cent for aluminum and 31 per cent for steel are less marked. The C-14 bonded joints characteristically failed in adhesion to metal, whereas the H2S bonds failed predominantly in cohesion in the adhesive.

The only way of determining the precision of a test method is to make a statistical analysis of a large number of test results. Such an analysis was made for each of the specimen groups tested in this work. The precision of the disk and lap shear test appears to be about the same. The standard deviation σ was calculated for each group of specimens. They vary between 159 psi and 442 psi, as shown in Table I. However, the three standard deviations marked with asterisks were tested at an early phase of the program and ranged from 384 to 442 psi. The five other groups were prepared twelve months later and ranged from 159 to 238 psi. This is definite indication that the precision of the two tests is equally good, and that precision depends primarily on the care exercised during the preparation of the test specimens. Probability curves for C-14 adhesive on both steel and aluminum are shown in Figure 6.

Adhesive Precision

It should be noted in Figure 6 that the precision of the C-14 adhesive results on the steel by the lap shear test is of a different order of magnitude than the results on aluminum and steel by the disk shear test. This is due to the fact that the results with a higher order of precision were obtained at a later date than the earlier results and represent improved techniques of the operator in preparing and testing specimens. It can be easily seen from this curve that both lap shear and disk shear have comparable precision and the disk shear strengths on both aluminum and steel are significantly higher than those of the lap shear test. Similar probability curves are given in Figure 7 for H2S adhesive. Here again, it is observed that a comparable order of precison is obtained for the lap and disk shear tests and that strengths for both etched aluminum and etched steel are higher by the disk shear test than by the conventional lap shear.

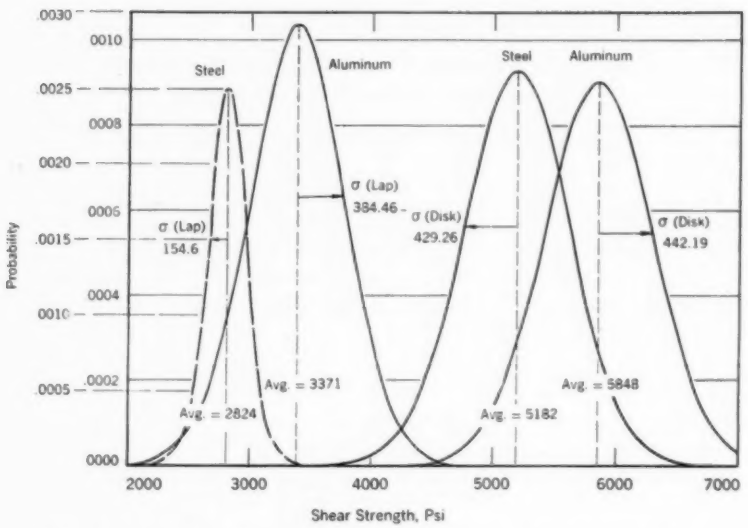


FIG. 6—Probability of Curves of Disk and Lap Shear Strengths—C-14 Adhesive.

Tests made at elevated temperatures give further evidence that peeling stresses due to eccentricity of loading in lap shear tests reduce the observed shear strength. The results of a comparison of the lap and disk shear tests at elevated temperatures are given in Table II. Only H2S adhesive was used in this study, since the C-14 epoxy adhesive is not suitable for the temperature range chosen. It can be seen that, as the testing temperature was increased, the differences in the two tests disappear.

As the adhesive became progressively softer, shear strengths became very low and the lap shear specimens were not loaded sufficiently to give significant distortion of the adherends. For this reason, no substantial peel forces were encountered at the highest test temperatures, and the lap shear and disk shear results are comparable. It is significant, however, that the lap shear strength of H2S adhesive on steel at 500°F is comparable to the strength of aluminum specimens at 400°F.

Effect of Steel Etching

Since extensive data on the effect of etching of steel on shear strength at elevated temperatures has not been published, it was believed of interest to compare the effect of etching, based on our small amount of data. These results for H2S adhesive are given in Table III. The effect of etching is relatively minor at room temperatures, ranging from 15 per cent for the lap shear test to 31 per cent for the disk shear test. The effect of etching is surprisingly great at the elevated temperatures of 400 and 500°F, ranging from 100 to 155 per cent. It is generally recognized that, with this type of rubber-resin cement, the limiting factor for shear strength at elevated temperature is softening of the cement and loss of cohesive strength. These results would seem to indicate that the adhesive component of shear strength is also important and is markedly affected by the method of surface preparation.

Increasing Load Rate

It has been shown that, at least for low modulus type adhesives, an increase in loading rate in lap shear testing increases the apparent shear strength of a bond.[5] This effect appears to be present for the disk shear test for both a low and high modulus adhesive, as demonstrated in Figure 8. A limited range of loading rates was used: 5 crosshead travel rates, ranging from 0.025 in. per minute to 0.5 in. per minute. Five specimens were tested at each rate. Both adhesives were tested using aluminum adherends. In spite of the limited range of crosshead travel, both adhesives required increasing stresses for breaking as the loading rate increased.

Conclusions

(1) Based on this preliminary evaluation, the disk shear test would appear to be a precise method of determining adhesive shear strength. The precision of the test is comparable to that of the lap shear test as determined by the standard deviation of a statistically adequate number of specimens.

(2) The disk shear test gives significantly higher observed shear strengths than the commanly-used lap shear test for both low modulus and high modulus adhesives and for

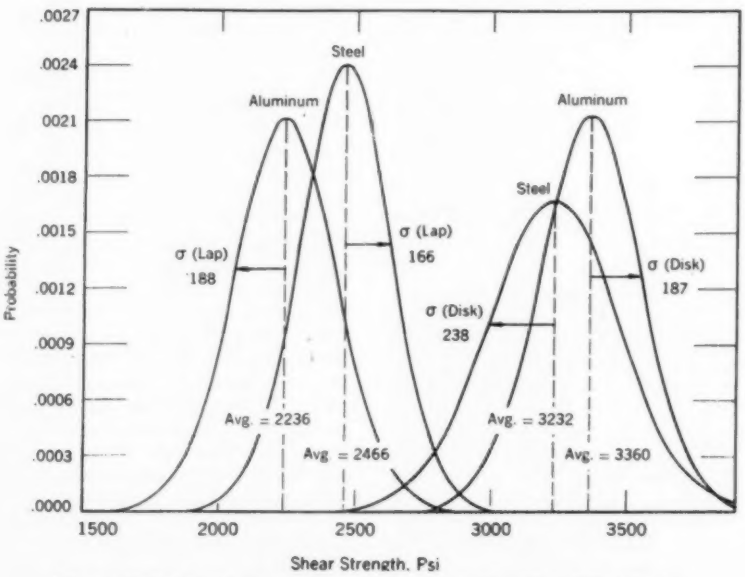


FIG. 7—Probability Curves of Disk and Lap Shear Strengths—H2S Adhesive.

two adherends, aluminum and steel. This is considered as evidence that peel forces have been substantially reduced in the disk shear test.

(3) The preparation of disk shear specimens is not especially complicated and requires no more time than the preparation of lap shear specimens, provided that several specimens are bonded simultaneously.

(4) As compared with the block shear test, the circular shape of the disk shear specimen gives the highly desirable feature of self-alignment when loaded in compression. It is probable that the disk has less concentration of stresses at the edge of the bond, although this effect has not been demonstrated directly.

(5) The effect of etching of steel adherends, in the case of bonding with H2S adhesive, has been shown to have a significant effect on the bond strength at room temperature and a marked effect on the bond strengths at elevated temperatures. This applies to both lap and disk shear testing.

(6) An effect of loading rate within a limited range appears to exist in the disk shear test for both low modulus and high modulus adhesives. Increasing rate of crosshead travel increases the observed shear strength.

(7) Further evaluation of the shear test is necessary before its scope and usefulness are established.

Table II—Comparison of Shear Strengths of H2S Adhesives at Various Temperatures

Test Temperature	Adherend*	Lap Shear Tests: Shear Strength, Psi	Lap Shear Tests: Std. Dev. (σ), Psi	Lap Shear Tests: No. of Specimens	Disk Shear Tests: Shear Strength, Psi	Disk Shear Tests: Std. Dev. (σ), Psi	Disk Shear Tests: No. of Specimens
Room Temp.	Aluminum	2236	188	24	3360	187	20
Room Temp.	Steel	2466	166	24	3232	238	20
300°F.	Aluminum	1010	178	10	1544	103	10
400°F.	Aluminum	511	98	10	1007	74	10
400°F.	Steel	1050	71	12	943	67	9
500°F.	Steel	500	90	12	370	35	9

*All metal specimens etched before bonding.

Table III—Effect of Etching* of Steel on Shear Strength—H2S Adhesive

Shear Test	Temperature	Without Etching: Shear Strength, Psi	Without Etching: Std. Dev. (σ), Psi	Without Etching: No. of Specimens	With Etching: Shear Strength, Psi	With Etching: Std. Dev. (σ), Psi	With Etching: No. of Specimens	Per cent Increase
Lap	Room Temp.	2145	211	24	2466	166	24	15
	400°F.	515	102	10	1050	71	12	104
	500°F.	196	64	10	500	90	12	155
Disk	Room Temp.	2468	151	24	3232	238	20	31
	400°F.	428	67	10	943	67	9	120
	500°F.	184	70	10	370	35	9	101

*5 minutes immersion in 10% sulfuric acid at 122°F.

Acknowledgement

Acknowledgement is made of the work of John Kermedjian, who designed and developed the heating fixture for elevated temperature testing of lap shear specimens.

Literature References

1 1955 Book of ASTM Standards, Part 6, p. 1040; Part 7, p. 1207.

2 1955 Book of ASTM Standards, Part 7, p. 1203.

3 DeBruyne, N. A. and Houwink, R., Adhesion and Adhesives, Elsevier Publishing Co., p. 96-7, 1951.

4 Eickner, H. W. and Schowalter, W. E., A Study of Methods for Preparing Clad 245-T3 Aluminum-Alloy Sheet Surfaces for Adhesive Bonding, Forest Products Laboratory Reports Nos. 1813 and 1813A.

5 Wittman, R. E., WADC Technical Report 54-153 (December, 1954).

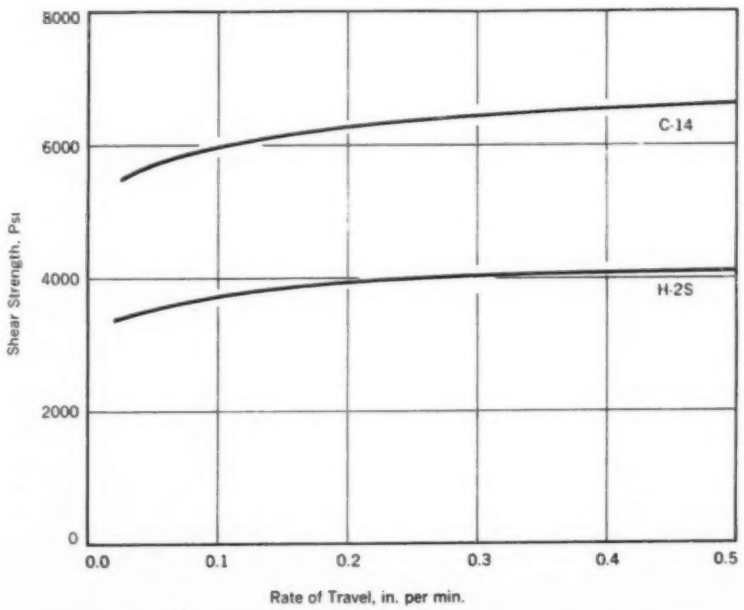


FIG. 8—Effect of Loading Rate on Disk Shear Strength—Aluminum Adherends.

About the Authors . . .

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ASTM Committee D-14 on Adhesives Reports on Recent Activities

At the 61st Annual Meeting of the American Society for Testing Materials held on June 22 to 27 at the Statler Hotel in Boston, Mass., Committee D-11 on Adhesives presented a report on its activities during the past year. While Committee D-14 and its subcommittees did not actually meet during the Boston sessions, committee officers did present a formal report on meetings held on October 31 and November 1 at the Sheraton Hotel in Philadelphia, Penna., and on April 2, 3 and 4 at the U.S. Forest Products Laboratory at Madison, Wisc.

Committee 14 recommended to the parent society that a number of methods and specifications covering a variety of subjects be adopted as tentatives. These were acted upon by the appropriate sections of the parent body and the following have been formally approved as tentative specifications or methods:

Bonding Permanency of Water or Solvent Soluble Liquid Adhesives for Labeling Glass Bottles (D 1581-58T). This method of test determines the bonding permanency of dextrin, casein, starch, animal gelatin, and other liquid adhesives (excluding pressure-sensitive types) used for applying printed paper labels to glass bottles.

Non-Volatile Content of Phenol, Resorcinol, and Melamine Adhesives (D 1582-58T). This method is suitable for determining the non-volatile content or total solids of phenol, resorcinol, and melamine adhesives with or without hardener added and containing high boiling and low boiling volatile organic solvents and/or water.

Measuring the Hydrogen Ion Concentration of Dry Adhesive Films (D 1583-58T). This is a method of determining the hydrogen ion concentration (pH), acidity or alkalinity, or organic adhesives in the cured dry film form. This method is not designed to apply to pressure-sensitive adhesives.

Water Absorptiveness of Paper Labels (D 1584-58T). This method of test covers the procedure for the selection of paper labels of uniform water absorptiveness for use in determining the bonding permanency of adhesives for labeling glass bottles. This method of test is for use in conjunction with the adhesive bonding permanency test described in D 1581-58T.

Filler Content of Phenol, Resorcinol and Melamine Adhesives (D 1579-58T). This test method is suitable for measuring the filler content of these types of adhesives when mixed with hardener or catalyst that set at room, intermediate and high temperatures. Results are expressed on the basis of the non-volatile content of the mixed, liquid adhesive.

Adhesives for Automatic Machine Labeling of Glass Bottles (D 1580-58T). This tentative specification covers starch, dextrin, casein, animal gelatin, and other liquid adhesives (excepting pressure-sensitive types) used for applying paper labels to glue bottles. It includes provision for adhesive selection based on satisfactory machining characteristics on specific labeling equipment, and adequate adhesion under specified storage conditions. This specification further provides for the control of uniformity between lots of an adhesive selected on the above basis by limiting variations in non-volatile content and viscosity.

Committee D-14's subcommittees have been quite active during the past year. It was reported at the Boston meeting that Subcommittee I on Strength Properties (C. E. Britt, chairman) is completing a Recommended Practice for Conducting Creep Testing of Metal-to-Metal Adhesives. An interlaboratory test program to determine the rate of loading to be specified in the Method of Test for Strength Preparation of Adhesives in Shear by Tension Loading (Metal-to-Metal) (D 1002-53T) has been completed and the data statistically outlined. Recommendations on this method may be made in the near future. The climbing drum test procedure has been revised by recent studies and is being prepared for presentation to the committee. The second draft of the T-Peel Test procedure is in preparation, as well as a proposed recommended practice for determining the suitability of chambers used to conduct extreme temperature exposures, and tests on adhesive bonded lap-shear specimens.

Subcommittee II on Analytical Tests (G. F. Lipsey, chairman) prepared the three proposed methods of testing hydrogen-ion concentration of dry adhesive films; non-volatile content of phenol, resorcinol, and melamine adhesives; and the filler content of adhesives, referred to earlier in this report. Methods under preparation include tests for non-volatile content and specific gravity of solvent-type resin adhesives.

Subcommittee III on Tests for Permanency (D. A. George, chairman) is preparing a method for the effect of natural molds on the permanence of adhesives and a recommended practice for the effect of weathering on adhesives while under stress. A study of the effects of nuclear radiation on the strength adhesive bonds is being considered.

Subcommittee IV on Working

Properties (N. J. DeLollis, chairman) is continuing work on the determination of pressure-sensitive tack. Methods for the measurement of flow properties, viscosity, and penetration of adhesives are being prepared.

Subcommittee V on Specifications (S. L. Adams, chairman) prepared for presentation to the Society methods for testing water absorptiveness of paper labels and bonding permanency of water or solvent soluble liquid adhesives for labeling glass bottles, and a specification for bonding permanency of water or solvent soluble liquid adhesives for labeling glass bottles, all referred to earlier in this report.

A specification for adhesives for acoustical materials has been developed for presentation to the committee. Methods under development include tests for the bonding permanency of adhesives for sealing top flaps of fiberboard shipping cases, the selection of fiberboard case samples for the bonding test, and adhesive sampling procedures. Specifications in preparation include adhesives for sealing top flaps of fiberboard shipping containers, general purpose (mending) adhesives, and polyvinyl acetate resin emulsion adhesives (alkali dispersible).

Subcommittee VI on Nomenclature (G. W. Koehn, chairman) has prepared 14 definitions for inclusion in Definitions D 907.

Subcommittee VII on Research Problems (J. E. Rutzler, Jr., chairman) has reviewed research studies in the adhesives field. Research reports were presented on: bonding with molten polymers and adhesive rupture before formation of oxide films in adhesive bonds. Involved problems to be included in "Challenges in Materials Research" have been chosen for preparation by the committee.

Subcommittee X on Wood Adhesives (A. A. Marra, chairman) presented a survey of adhesive testing in the fields of plywood, laminations, and assembly gluing. Representatives of the Forest Products Laboratory and the Hardwood Plywood Institute reviewed the activities of their organization with regard to research and control testing of plywoods and assemblies. The subcommittee is preparing a detailed questionnaire to circulate to those in a position to contribute to the development of test methods for wood-to-wood adhesives.

New sections formed in the subcommittee were set up on the basis of glued products which are presumed to demand similar properties in adhesives and thus utilize similar test methods, as follows: Section A on Lumber Adhesives (R. F. Blomquist, chairman), Section B on Veneer Adhesives (John Butler, chairman), Section C on Assembly Adhesives (R. F. Snider, chairman), Section D on Pulp and Particle Board Binders (A. A. Marra, chairman), Section E on Adhesives for Bonding Wood to Other Materials (C. B. Hemming, chairman), and Section F on Special Problems (Ben Jayne, chairman).

Subcommittee XI on Metal Bonding Adhesives (F. H. Bair, acting chairman) has organized four sections as follows: Section A on Mechanical Properties, Section B on Durability, Section C on Metal Surface Preparation, and Section D on Inspection and Quality Control.

This new subcommittee is currently reviewing existing methods to determine if revisions are necessary. New methods which are being considered for development include evaluation of surface preparation, and procedures which are of particular interest to the aircraft industry.

Brick-Like Wallpaper

Wallpaper that looks like brick has been patented by Lester A. Diamond of Westwood, N. J. The wallpaper consists of slabs of cork about one-half inches thick, which simulates brick, glued to a sheet of adhesive-backed paper. Cut to size and painted to match bricks, the slabs are spaced with a material of the same color, which looks like mortar. Mr. Diamond plans to cut the paper into panels that fit together along their edges the way bricks fit. A modified form imitates field stones. The patent, No. 2,847,721, is owned by Bernard and Joseph Sage of New York.

Georgia-Pacific Corp., has transferred one of its three plywood plants at Olympia, Wash., to the **Simpson Logging Co.** Transfer of the plant, which has been shut down since July 31, included purchase of equipment and long-term lease of the building. Terms were not disclosed.

Adhesives Symposium At ASME Meeting

The Annual Meeting of the Rubber and Plastics Division of the American Society of Mechanical Engineers scheduled to be held on December 3 and 4 at the Hotel Statler in New York City, will feature a Symposium on Adhesives. D. M. Alstadt (Lord Mfg.), will serve as chairman for the symposium which will get under way at 9:30 A.M. on December 3. R. F. Westover (Bell Telephone Laboratories), will serve as vice-chairman. Five papers have been scheduled for presentation at the session:

"Epoxy Resins and Their Applications as Adhesives," by D. Richart, S. H. Richardson and C. F. Pitt, Bakelite Co., New York, N.Y.

"The Strength of Curved Glued Laminated Wood Timbers as Affected by Radius of Curvature and Lamination Thickness," by William J. Finnoran, Timber Engineering Co., Washington, D.C.

"Control of Flexural Strength of Glass-Fiber Resin Laminated by Glass Surface Treatment and Theoretical Implications," by Nicholas M. Trivisonno, B. F. Goodrich Research Center, Brecksville, Ohio.

Other Papers Scheduled

The symposium will also include two other papers, one on "Recent Developments in Reinforcement" by William E. Dirkes of the Wright-Patterson Air Force Base, Dayton, Ohio, and "Prediction of Load and Creep Deflection in Beams and Eccentrically-Loaded Members" by O. M. Sidebottom and S. Dharmarajan of the University of Illinois, Urbana, Ill.

In addition to the Adhesives Symposium, the Rubber and Plastics Division meeting will include two other symposiums. One of these will be devoted to "New Materials and Significant Research on the Physical Nature of Plastics," while the other will be concerned with "Design of Engineering Properties in Plastics."

Plans Epoxy Resin Unit

Union Carbide Corp., New York, N. Y., has announced plans to build a new plant for the production of Bakelite liquid epoxy resins at Marietta, Ohio. The facilities, scheduled for commercial operation early in 1959, will have a rated annual capacity of 15,000,000 pounds of epoxy resins.

New Directions for Adhesives in Construction . . .

Recent CCDA Meeting Points Up Opportunities in Building Field

In a recent address before the Commercial Chemical Development Association in Niagara Falls, N.Y., D. W. Maher, merchandising manager of the Adhesives and Coatings Division of the Minnesota Mining & Manufacturing Co., pointed to an ever-growing use of adhesives in the construction industry. Speaking on "New Directions for Adhesives in Construction," Mr. Maher stated that adhesives lend themselves to pre-prepared or prefabricated building components to which builders are being driven by high job site labor costs and by a diminishing force of skilled labor.

Structural Adhesives

Much emphasis has been recently placed on the development of what are becoming known as high strength structural adhesives. These are products, in a variety of forms, that create bonds that usually equal and sometimes exceed the strength of the materials they hold together. At this point, Mr. Maher exhibited several new products which fall into the structural adhesives category. One of these was a film adhesive originally developed for the aircraft industry. When it is placed between two objects that are to be bonded together and subjected to heat in the order of 350°F. and pressure of about 100 psi is applied, the film liquefies and chemically cures to a thermosetting adhesive providing a bond strength of 10,000 pounds per square inch.

Modified Type

A modification of this film adhesive is a type that employs two different types of adhesives in the same film in order to bond two dissimilar materials together. He also discussed adhesives which are 100 per cent solids, but which are liquid or semi-liquid in form. Such products employ constituents which have no volatile or evaporable characteristics. Thus, they may be brushed, sprayed or trowelled into place. These products remain dimensionally stable in the sense that they do not shrink or change in volume. They do not "dry" as solvent or water-base adhesives do. Instead, they chemically cure to their final state.

Contact Bond Adhesives

Also discussed were contact bond adhesives and a new product which, while very liquid in form, bonds to high strength when deprived of oxygen. In the flooring business, adhesives have been developed that will perform satisfactorily regardless of hydrostatic pressures and general conditions of moisture. There are also adhesives products available which make joints in rigid plastic pipe and with which to attach metal fittings to such a pipe.

Mr Maher is of the opinion that the adhesives manufacturer is now in a position to offer a great many new and versatile products to the construction industry. A substantial part of the answer to the question as to where adhesives will be used depends on the degree to which the construction industry will go in adopting techniques that lend themselves to adhesives bonding.

Preformed Roof Sections

The speaker noted that an asphalt shingle roof for an average size house requires 11,000 nails and that carpenters and probably roofers, cost 9 to 11¢ per minute. To meet this kind of a problem, large, preformed roof sections that are adhered into place may be the answer.

The light metal, steel and plastic manufacturing industries have already come a long way in the development of curtain wall components for large buildings. Completely preformed bathrooms that can be lifted by a crane into a roofless house, hooked up to a water supply brought by rigid and flexible plastic piping is another future possibility, Mr. Maher stated.

Soft Acoustic Walls

Soft walls with good acoustic values are being talked about as are sandwich panel doors and perimeter walls that combine decorative wear-resistant surfaces with insulation properties and which can be preformed into relatively large sections. Floor, wall and sink counter top coverings that can be adhered to a subsurface are other likely uses for adhesives, the Minnesota Mining executive declared.

The goal of economic and practical construction techniques means new opportunities for adhesives in—

- **Preformed roof sections which can be adhered into place.**
- **Curtain wall components for large buildings.**
- **Preformed bathroom assemblies.**
- **Soft walls with good acoustic values.**
- **Perimeter walls preformed into large sections.**
- **Floor, wall and counter top coverings which can be adhered to a subsurface.**
- **Sandwich panel doors.**

News Briefs

Shell Chemical Corp. has reduced prices of Epon resins as much as 20 per cent, retroactive to August 15. The delivered tank car price of Epon 828, representative of the liquid resins, was trimmed from 77 to 66¢ a pound, while the price of 1004, a solid resin, was reduced 6¢ to 53½¢ per pound. The company said that it hoped to increase the demand for the resins, now that techniques for most applications had been developed.

American Seal Kap Corp., 11-04 44th Avenue, Long Island City, has leased a building to be erected to its specifications on a site across the street from their present location. The new plant, to contain 13,000-square feet of space, will be used to expand Seal Kap's container manufacturing facilities.

Frigidaire Division of General Motors has announced that it plans to recall an additional 350 employes at its Dayton, Ohio, plant. Company spokesmen said the recall of 400 men and women, announced several weeks ago, is about completed. They said because of the continuing favorable sales outlook for Frigidaire appliances, about 750 people will eventually be returned to the plant.

E. L. Bruce Co., Memphis, Tenn., reported it has issued 10,000 common shares to acquire **Welsh Plywood Corp.**, also of Memphis. A Bruce spokesman in New York asserted the action would forestall the attempt by Edward M. Gilbert to gain control of Bruce. In a joint anouncement, officials of Bruce and Welsh said that 10,000 authorized but unissued Bruce shares were exchanged for all the capital stock of Welsh, a maker of hardwood plywood wall panels.

American Marietta Co. has begun work on a $1 million synthetic resin research center at Seattle, Wash. The center will serve the **Adhesive, Resin & Chemical Division** with plants in the Northwest and Canada and the **Booty Resineers Division**, Newark, Ohio. The new center, which is expected to be completed early next year, will add more than 30,000-square feet to the present 8,500-square foot research and administrative building.

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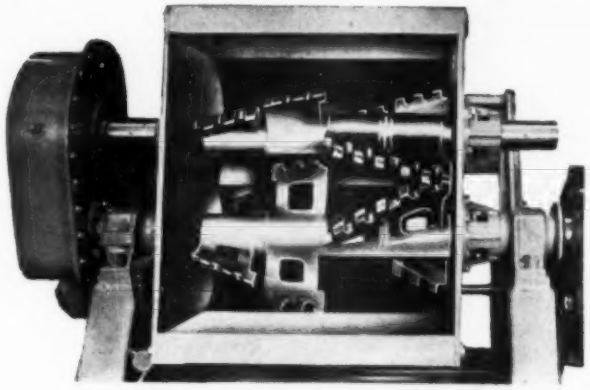

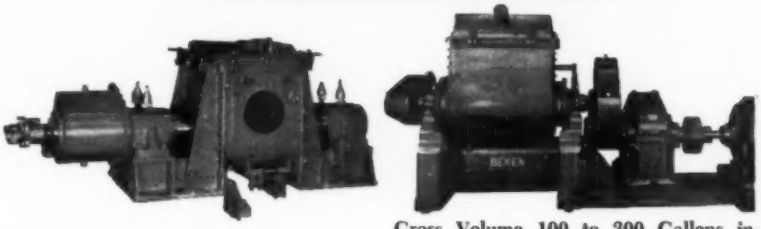

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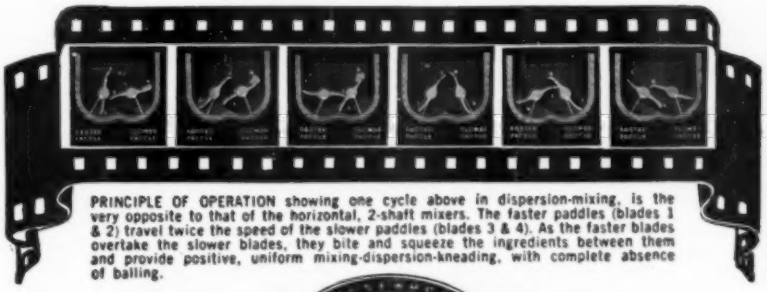

PRINCIPLE OF OPERATION showing one cycle above in dispersion-mixing, is the very opposite to that of the horizontal, 2-shaft mixers. The faster paddles (blades 1 & 2) travel twice the speed of the slower paddles (blades 3 & 4). As the faster blades overtake the slower blades, they bite and squeeze the ingredients between them and provide positive, uniform mixing-dispersion-kneading, with complete absence of balling.

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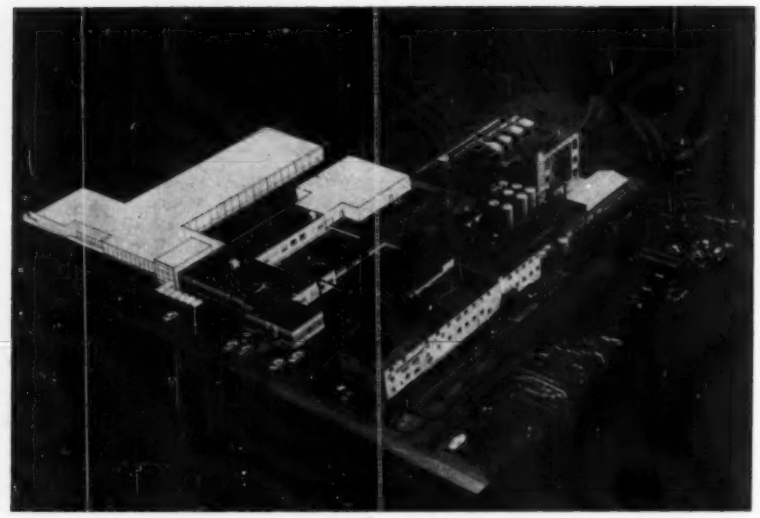

American-Marietta Research Center

American-Marietta Co. is now constructing a new $1,104,000 Synthetic Resin Research Center at Harbor Island, Seattle, Wash. Basic research will be conducted by the new laboratories for the entire Adhesive, Resin & Chemical Division, with plants located at Seattle, Portland, New Westminster, B.C., and Edmonton, Alberta, and the Booty Resineers Division, Newark, Ohio.

Company officials have indicated their intention to erect an architecturally aesthetic building which will utilize various engineered forest products. The structure will be unique through the application of new technology in utilizing wood in combination with other materials—both aesthetically and structurally.

As planned by the engineering and architectural staffs of American-Marietta, the expansion will add more than 30,000 square feet to the present research and administrative building which now comprises about 8,500 square feet. The present building will be completely renovated.

The new resin research center will consist of twenty-one unit laboratories and six process development areas; also, areas and equipment for the evaluation and testing of wood products manufactured throughout the Northwest. As designed and equipped, these laboratories will provide complete facilities for research, engineering, and technical services.

The new research laboratories will facilitate programs in the following fields: Basic and Applied Research (Urea, Melamine, Phenolic, and Specialty Resins, and Protein Adhesives); Product Development (Plywood, Consolidated Board, Paper and Special Adhesives); Process and Equipment Development, and Analytical Research. In addition, an enlarged technical library will be available as a research aid.

The new technical service laboratories will facilitate solving customers' production problems and answering inquiries rapidly. New quality control laboratories for both synthetic resins and protein adhesives will be constructed. American-Marietta's expansion will provide new quarters for the sales, accounting, purchasing, personnel, production, and executive staffs; also, conference rooms, as well as an auditorium.

Company officials have expressed considerable optimism over the future of the cellulosics field, also recent developments in the mineral wool, glass fiber, and shell molding fields. They believe that the Northwest is the most advantageous location for this type of research center —where the objective of American-Marietta's research has been primarily forest products which are indigenous to this region.

The new laboratories will develop chemical products for marketing on a national scale and throughout Canada. Recent acquisition in August, 1957 of Booty Resineers, Newark, Ohio, has provided mid-western production facilities and hastened development of eastern and southern sales outlets for American-Marietta's synthetic resins.

Civil Service Examinations

The United States Civil Service Commission is conducting examinations for technologists in order to fill positions in various federal agencies in Washington, D. C., and throughout the country. The examinations cover a wide variety of specialized fields including Adhesives; Bituminous Products; Ceramics; Drugs and Chemicals; Food Preparation Equipment and Food Logistics; General; Glass; Leather; Medical Supplies and Equipment and Prosthetic Devices; Military Apparel and Equipage; Miscellaneous; Paints and other Protective Coatings; Paper and Pulp; Petroleum Fuels and Lubricants; Photographic Processes and Supplies; Solid Fuels; Textiles and Textile Fibers; Aviation Survival Equipment; Industrial Radiography; Packaging and Preservation; Photographic Equipment; Plastics; Rubber, and Rubber and Plastics. In order to qualify, applicants must have had appropriate experience in one or more of these fields. Further information may be obtained from the United States Civil Service Commission, Washington 25, D. C.

Morningstar Profits Up

Morningstar-Paisley, Inc., New York, N. Y., has reported a net profit of $250,911 in the six-month period ended June 30, 1958, a 10 per cent increase over the 1957 first-half figure of $228,209. This amounts to net earnings of 50¢ per share, compared with 46¢ per share in the first half of 1957, with both figures based on the 494,255 shares outstanding June 30, 1958. Consolidated sales in the first half of 1958 totaled $10,737,936, compared with $9,728,767, in the same period a year ago. Earnings during the second quarter of this year were 18 per cent above those of the first quarter.

U. S. Plywood Sales Up

U. S. Plywood Corp., New York, N. Y., has announced that in the first quarter of its fiscal year, ended July 31, the company has earned $2,057,000, which is equal to 81¢ a share on 2,389,926 common shares outstanding. During the corresponding quarter of last year, the company earned $1,806,000, or 71¢ per share. Sales during the first three months of this fiscal year were $53,362,000, the largest for any first quarter period in the company's history, compared with $52,391,000 in the corresponding 1957 first quarter.

Adhesives Theme Of CMRA Meeting

Several hundred chemical industry executives representing United States and Canadian companies are expected to attend the National Meeting of the Chemical Market Research Association on November 12 and 13 at the St. Paul Hotel in St. Paul, Minn., which will be devoted to the theme of "Adhesives". Three prominent speakers will address the meeting on various aspects of the adhesives industry, including R. F. Blomquist (U. S. D. A.); D. W. Maher (Minnesota Mining), and R. E. Smith (H. B. Fuller). The speakers will emphasize the nature and size of the markets for adhesives and will also discuss future trends.

Case History Discussions

The "Market Shop", another feature of the meeting, will consist of panel discussions on case histories of the methods of marketing research which have led to the commercialization of several new chemicals. Chemicals to be considered at the panel discussions are adhesives, polyethylene, fluorocarbons and epoxy resins. Panel speakers are W. H. Bromley (Shawinigan Resins); James Dillon, Sr. (National Starch); W. L. Machmer, Jr. (Allied Chemical), and E. W. Segebrecht (Spencer Chemical).

Also scheduled are after dinner talks by Harry A. Stuhldreher (U. S. Steel) and Dr. L. M. Gould (Carleton College). The program will be rounded out with conducted tours through several local manufacturing plants and an overnight trip to tour the new taconite plant at Silver Bay, Minn.

Program and Arrangements

The program and arrangements will be handled by local members of the C. M. R. A. Committee chairmen are: **General Chairman**, D. H. Thomas (First National Bank of St. Paul); **Plant Tours**, M. H. Baker (M. H. Baker); **Program**, D. A. Beadell (Archer-Daniels-Midland); **Publicity**, H. A. Hamilton (General Mills); **Registration**, S. L. Hopwood, Jr. (Minnesota Mining); **Arrangements**, H. C. Paulus (Minnesota Mining), and **Treasurer**, J. L. Randall (Minnesota Mining). Assisting are R. G. Freese and V. C. Bidlack (Archer-Daniels-Midland); A. E. Reynolds (Minnesota Mining), and R. B. Scott (N. S. P).

Adhesive Usage Increasing

A. G. Battaglia, manager of the Structural Products Division of National Starch Products, Inc., New York, N. Y., forecast that adhesives will find an increased number of applications in a statement released in conjunction with National's exhibit at the current Design Engineering Show. He said "Structural Adhesives, tailored to meet the wide range of demands created by today's diversified designs in architecture, furniture, transportation and manufacturing processes, will expand their use to still other areas." Mr. Battaglia pointed out that "adhesives and the art of gluing now constitute an intricate science." He added that bonding such dissimilar materials as plastic foams to steel, honeycomb to wood and metal, aluminum foil to hardboard for reflective insulation or moisture vapor control, and vinyl of polyester plastics to hardboard for interior automotive trim, is becoming quite common.

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Morningstar-Paisley Acquires Gum Firm

In June of this year Morningstar-Paisley announced that an agreement had been signed for the acquisition of Thurston & Bradich, importers and processors of water-soluble gums. The combined operation, which became effective in July is now claimed to be one of the most modern, fully integrated processors of water-soluble gums, from the raw material to the finished product.

All manufacturing operations are done at Morningstar's recently completed gum processing plant in Hawthorne, N. J. Thurston & Bradich has been moved from its old six-story building at 286 Spring Street to Morningstar's offices at 630 West 51st Street. The pooling of purchasing, manufacturing, and sales servicing is expected to lead to more efficient operations, company officials declare.

The integration will increase the availability of scientifically selected, processed and controlled gums. The trend is away from gum selling on a simple telephone trading basis, where the supplier only imports the gum and has it processed on a commission basis.

According to Mr. George J. Muller, president, "Pooling of technical knowledge will give all water-soluble gum users a reliable and uniform source of supply to meet their specific requirements. In addition, it sets the stage for the development of remarkable new gum products, particularly those made from gum-starch combinations. Finally, Thurston's vanilla bean importing business gives us another addition to our fast-growing line of food items."

Both firms are well over 100 years old: Morningstar, founded in 1851, is a manufacturer of starches, dextrines, adhesives, and specialty food and chemical products. It entered the gum field on a large scale when it purchased the gum department of Innes Speiden from International Minerals & Chemicals Corp. in 1952. Thurston & Bradich, which began operations in 1856, is probably the oldest gum importer and processor in the country.

Union Carbide Antifoams

Silicones Division of Union Carbide Corp., New York, N. Y., has introduced "SAG Antifoams," which are said to be new, fast-acting and highly effective foam killers for industrial use. The new products come in two forms "SAG 47" silicone antifoam fluid for non-aqueous systems, and "SAG 470" silicone antifoam emulsion for aqueous foaming systems. Developed to fight foam quickly, only small quantities of these antifoams are required, often between 10 and 200 parts per million.

SAG 47 silicone antifoam fluid is a 100 per cent solid solution which can be used at full strength, as a solvent solution, or blended with other materials. SAG 470 silicone antifoam emulsion contains 10 per cent silicone solids by weight and is ready for use but can be further diluted. According to Union Carbide, the new antifoams can be effective in the manufacture of adhesives and glues; synthetic resins and polymers; cleaners, solvents, soaps and detergents; dyes, inks and pigments; drawing compounds, distillations, vegetable oils; paints, varnishes and lacquers, and paper making.

Reports Lower Earnings

United Wallpaper, Inc., and its subsidiary have announced net earnings of $3,175,430 in the fiscal year ended June 30, 1958, as opposed to earnings of $3,340,448 the year before. Figures for 1957 include only 11 month operations of the paint and wallpaper facilities acquired by the company on August 1, 1956. Earnings this year, per common share, were 92¢, 5¢ less than last year's per share earnings. The company also announced net sales of $40,897,029 for the 1958 fiscal year, compared with $38,389,473 last year.

Develops Hodag PX-1

A new chemical formulation, called "Hodag PX-1," for use as a replacement for pine oil, has been developed by the Hodag Chemical Corp., Chicago, Ill. A proprietary combination of alcohols, hydrocarbons and surface-active chemicals, the formulation is used as an antifoam, leveling agent, and solvent in a broad range of applications in which "preservative" properties are not required.

Changes Price Policy

Naval Stores Department of the Hercules Powder Co., Wilmington, Del., has announced a change in its pricing policy for pale grades of Hercules wood rosins. Effective October 1, 1958, rosin prices will be quoted firm for three months and will be subject to change on a quarterly basis. The company states that the use of daily fluctuating markets as a determining factor in establishing pale wood rosin prices is undesirable as commodity buyers have, for many years, expressed a strong preference for more stable prices. Approximately two weeks prior to October 1, Hercules will announce prices for all grades of pale wood rosins for the last quarter of 1958 and thereafter, prices will be subject to change on a quarterly basis effective the first day of each calendar quarter.

Flintkote Plans Merger

Officials of the Flintkote Co., New York, N. Y., and the Hankins Container Co., Cleveland, Ohio, have reached an agreement to merge subject to approval by board and stockholders of both concerns. The merger calls for an exchange of 1.234 shares of Flintkote common stock for each of the 267,458 shares of Hankins capital stock. About $16 million of Flintkote shares would be involved, based on a closing price of $48.50 on August 15 for Flintkote shares on the New York Stock Exchange. Pending approval of the directors of both firms, a formal merger agreement was to have been drawn up at a special meeting of Flintkote shareholders, which was scheduled for October 14.

Sun Buys Coatings Firm

Sun Chemical Corp., Harrison, N. J., has purchased the Coating Materials Laboratories, Nutley, N. J., manufacturers of a diversified line of industrial coatings and finishes. A cash purchase, the acquisition is a part of Sun's long range expansion and modernization program. Coating Materials, which grossed more than $1 million in sales last year, will be operated as an autonomous division in Sun's Paints and Finishes Group. Dr. H. A. De Phillips, president and general manager of the Laboratories and his staff will continue in the same capacities under the new management.

Dow Solid Epoxy Resins

Dow Chemical Co., Midland, Mich., has developed three new solid epoxy resins, designated D. E. R. 661, 664 and 667. Dow claims that its new resins have superior purity and therefore, the dissolved resins may be processed without filtering, which results in decreased costs and more uniform performance. The resins have a color rating of one maximum, compared with ratings that range as high as eight maximum for conventional products. They are also said to have better electrical and coating performance and a very narrow specifications range.

D. E. R. 661 is a low molecular weight resin for catalytically cured coatings and can be cured at room or slightly elevated temperatures; 664 is useful in ester type one-component systems needing no curing agent and 667 is catalytically cured, requiring high baking temperatures, and gives maximum flexibility and toughness. The resins will find application in coatings for appliances, auto body primers, cans, drums, tank-cars and for industrial maintenance and may also be used in glass reinforced laminates for aircraft structures, adhesives and electrical printed circuits.

Crash Device Tested

The Westchester Parkway Authority is using a compound of traprock and adhesives in an experiment to reduce head-on collisions of automobiles on the outmoded Cross County Parkway, where 11 motorists have been killed in two months. The compound was poured in a line 18 inches wide for 100 feet along the center of the parkway. When the tires of a car touch the rough center line, a driver is supposed to hear the noise and feel a jiggling of the wheels. The Authority has reported that it also plans to test metal and plastic objects spiked to the center of the parkway.

Sets Two Scholarships

Central Solvents and Chemicals Co., Chicago, Ill., has established two new scholarships at Illinois Tech for students who plan to work in the adhesives, paint, chemical or metal fabrication industries. Called the William J. Hough Scholarships, in honor of the company's founder, the scholarships will provide $400 a year for each of two students with either junior or senior standing in chemical engineering.

Announces Price Reduction on Trimethylolphenol

Trimethylolphenol, produced by the Bakelite Co., division of Union Carbide Corp., New York, N. Y., is now available at a 40 per cent price reduction from the company's Bound Brook, N. J., plant. Increased production from pilot plant quantities based on twelve months of successful field tests, prompted the slash from 35¢ to 21¢ per pound in truckload quantities for the phenolic material. It is marketed as a 70 per cent aqueous solution and designated "BRLA-1030." BRLA-1030 may be used in bonding, coatings and adhesives, starch and dextrin modification, electrical grade laminates, beater additions in the pulp and paper field, curing agents for novalaks and bonding wood products.

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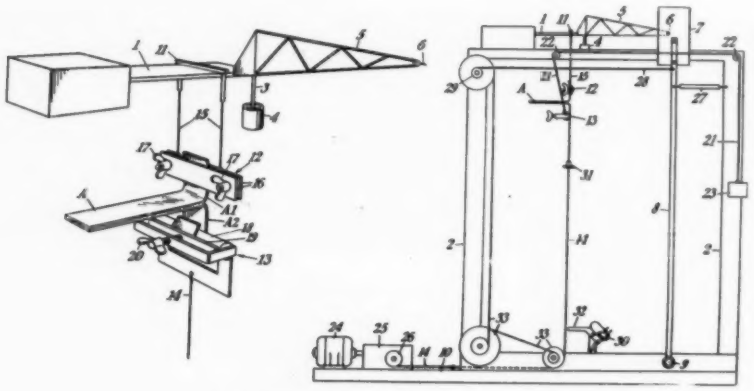
Portable Glue Mixer Bulletin 11-IS
No. 700 Series Glue Heater Bulletin 11-H
Rotary Press Bulletin 11-C
Motorized Laminating Press Bulletin 11-E
Air Hose Laminating Press Bulletin 11-D

By MELVIN NORD

Adhesion Testing Machine

U.S. Patent 2,834,205, issued May 13, 1958 to Bryan Pickup, assigned to Dunlop Rubber Co. Ltd., describes a machine for testing the adhesion between two materials by measuring the force required to strip them apart at constant speed.



Schematics of adhesion testing machine.

Heretofore it has been customary to perform such tear-down testing by mounting a testpiece composed of a strip of each material in an autographically recording tensile testing machine, the strips being gradually torn away from each other as the jaws of the machine are drawn apart. In general, the force required to separate the two materials is not constant over the length of the material, and false readings of the tear-down force from point to point along the length of the testpiece are obtained because of the effects of the high inertia, low natural frequency of vibration, and lack of damping of the test machine.

As seen in the diagram, which shows two views of the apparatus, a mild steel rectangular section beam (1) 2½ inches long and having a natural frequency of 100 cps when provided with the attachments described below, is clamped rigidly at one end at the top of a rectangular framework (2). Attached to the free end of the beam is a damping plunger operating in a dash pot (4) filled with thick oil to give a damping force which is 0.2 times the critical damping force for the beam and its attachments. A light pointer (5) extends outward from the free end of the beam and carries a steel stylus (6) arranged to contact a soot-covered surface of a glass slide mounted in a holder (7) positioned at the top end of a vertical steel beam (8) pivoted on a ball race (9) at its lower end to a base plate (10) supporting the framework (2). The length of the pointer is seven inches and it is sufficiently resilient in a horizontal direction to ensure that the stylus is always lightly touching the slide.

The beam carries a knife edge (11) from which hang two wires (15) supporting a clamp (12) consisting of two light-alloy metal strips (16) forced together by thumb-screws (17). A second clamp (13) is attached to a wire (14) from a pulling mechanism so that it may be pulled downward away from the first clamp (12), and consists of a cylinder (18) around which an end of a specimen strip may be wound and a thumb-screw (20) to grip the end of the strip against the cylinder. The second clamp (13) is lifted to the top of its travel when the machine is not in use by two wires (21) passing over pulleys (22) at the top of the framework and attached to a weight (23). The upward pull on the second clamp, due to its return mechanism, is constant throughout its range of movement.

The pulling mechanism consists of an electric motor (24) on the base plate driving a variable speed gearbox (25). The wire (14) from the second clamp (13) is attached to the output spindle (26) of the gearbox. The steel beam (8) carrying the slide holder (7) is attached to the framework by a tension spring (27) and is moved against

Introducing Melvin Nord . . .

A monthly feature of ADHESIVES AGE, this column reviewing patents of interest to the adhesives industry is conducted by Dr. Melvin Nord. Exceptionally well qualified for this task, Dr. Nord holds four degrees including a doctorate and a law degree. In addition, he is a chemical engineer and has served as an associate professor of chemical engineering at Wayne University, Detroit, Mich. Dr. Nord, the author of a number of technical and legal articles, conducts a monthly column on patents for RUBBER AGE magazine. He is an active member of many professional organizations, among them AICHE, AAAS, Sigma Xi, ACS, the National Society of Professional Engineers, and the Engineering Society of Detroit. He is a registered professional engineer, a registered attorney, and a member of the Michigan and Federal Bar Associations. During his career, he has done extensive consulting work in patents and equipment and process design. At the present time, Dr. Nord is a member of the patent law firm of Colman, Nord and Krass in Detroit. From time to time he teaches law courses at Wayne State University and the University of Detroit. His column in ADHESIVES AGE will be devoted to a survey of currently issued patents pertinent to the industry. It will supply information of direct interest as well as provide coverage of an important segment of the technical literature.

the spring tension by a cord (28) attached to a spindle (29) which rotates with the movement of the wire pulling the second clamp downward through a wire and pulley arrangement. The slide then moves at a speed proportional to that of the second clamp. A mercury switch (30) is incorporated into the mechanism so that the motor is switched off when the second clamp (13) reaches the lower limit of the travel, a trip (31) on the wire contacting the switch arm.

To test the adhesion of two layers of material a specimen strip eight inches long and one inch wide (A) is prepared and the layers at one end are separated for a short distance. One layer (A1) is clamped between the strips (16) of the first clamp (12) and the second layer (A2) is secured to the second clamp (13) as described. The motor is switched on, the speed of the output side of the gearbox being set to give a predetermined speed of separation of the two layers as the second clamp (13) is drawn downward.

As the test proceeds, the variation in the stripping force between the layers A1 and A2 is indicated by a trace made on a slide in the holder (7) by the stylus (6) attached to the pointer (5) on the end of the beam (1). For examination and measurement it is convenient to magnify the trace of the slide 30 times on an optical projector.

Starch Adhesives

U.S. Patent 2,833,662, issued May 6, 1958 to Levi M. Thomas and Thomas J. Neel, assigned to National Industrial Products Co., describes a method of making wheat and corn starch adhesives which are useful in the manufacture of corrugated board.

In making corrugated paper board, the adhesive is circulated to and from pans in which the adhesive supplying rolls continually dip as they rotate, causing an agitation of the adhesive. This agitation has heretofore had a pronounced and deleterious effect on the viscosity of the adhesive. However, by using the starch product disclosed in this patent, the viscosities of both a gelatinized starch which serves as a carrier and an ungelatinized starch which is carried by the former, after an initial adjustment period of about 30 minutes, remain substantially constant at a favorable viscosity for many hours.

The gelatinized starch is prepared as a carrier. From 30 to 52% of dry raw wheat starch and 48 to 70% of dry raw pearl corn starch are mixed, and this wheat-corn starch preparation is mixed with water and borax. A large amount of the raw starch mixture is then mixed with the gelatinized starch.

Edge-Gluing Wooden Elements

U.S. Patent 2,834,705, issued May 13, 1958 to Stephen Marcucio and Harold Brodsky, assigned to American Cyanamid Co., describes a process for edge-gluing wooden elements. Their edges are coated with a layer of an adhesive, the edges are tightly clamped together, and the adhesive is cured by the passage of a high-frequency electric current through it.

The adhesive composition consists of 75 to 86% of a urea-formaldehyde condensation product (in which the mol ratio of urea to formaldehyde is from 1:1 to 1:2), 10 to 20% of a melamine-formaldehyde condensation product (in which the mol ratio of melamine to formaldehyde is from 1:3 to 1:4), 1 to 2% of a hardening ingredient (ammonium fluosilicate or ammonium borofluoride), the balance being a metallic soap.

Other Patents of Interest

Subject	Inventor or Assignee	Patent No.	Date
Device for applying liquid adhesive	Fritz E. Breuhan	2,832,981	5/6/58
Adhesive repair patches for tire tubes	Reginald D. Boyce	2,833,327	5/6/58
Tape applying machine	Minnesota Mining & Manufacturing Co.	2,833,438	5/6/58

Copies of any patents, including those described here, are available from the Commissioner of Patents, Washington 25, D. C., for 25 cents each. Do not send stamps.

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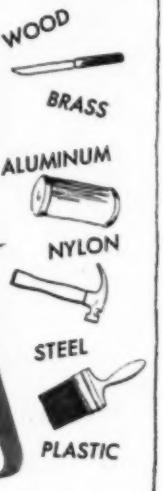

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new equipment

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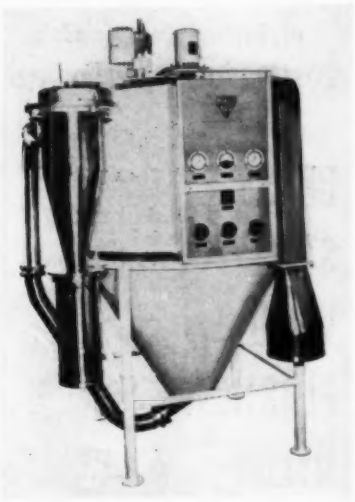


Nichols Spray Dryer

signed for a water evaporation rate up to 100 pounds per hour and assures a gentle spray drying of heat-sensitive materials, the company claims. The ease and speed with which the unit is said to be cleaned is of particular interest to producers of materials where inter-contamination between batches must be avoided and change-over time kept to a minimum. All contact surfaces are stainles steel. Evaporation capacity ranges from 20 to 100 pounds per hour. Over-all dimensions of the unit are: length 5 5/6-feet, width 5 1/3-feet, and height 3 1/3 feet. *Nichols Engineering and Research Corp.* **E-1**

FOR MORE INFORMATION on the new equipment items described here, use the Reader's Service Card elsewhere in this issue.

Resin Dispenser

A positive displacement resin dispenser for use with liquid resin and hardener systems has been announced. Accurately calibrated to meter both liquid hardeners and resin in exact proportions, it is designed to eliminate the necessity for time-consuming weighing operations. The resin material is metered through drip-proof valves. Both hand-driven and motor-driven models are available, the latter with or without explosion-proof housing on the motor and switch. The dispenser

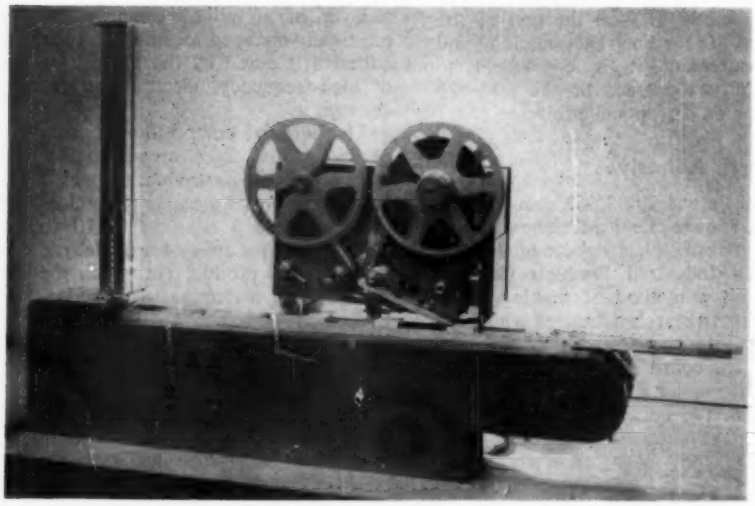
Delsen Resin Dispenser

is said to function satisfactorily for most two-component adhesive and coating systems. *Delsen Corp.* **E-2**

Automatic Labeler

A new fully automatic labeling machine for pressure-sensitive labels has been introduced which is said to apply labels of any shape or size in exact register on nearly all surfaces at assembly line speeds. Labels, die-cut and printed to specification, are furnished in rolls of quantities that may go up to 20,000 per roll. The labels are fed to an impressor which applies them individually to a specific position on the product being labeled. As the impressor removes the label from the peeling edge, a dispensing switch provides another label and the backing tape is carried away by an automatic rewind unit.

The Model 100 Labeler, as the machine is designated, is designed to apply labels from ¼-inch square to 2¼ x 6 inches, but may be modified to handle other sizes. The reels, though standardized at 10½ inches, are also adaptable in size. The labeler, powered by a 110-volt, 60-cycle, 1-phase motor, is 15 inches high with reels in place, 9¾ inches wide and 19 inches long. It may be mounted on its side, vertically or upside-down, or used with a second machine to apply labels to two sides of a package simultaneously. *Avery Adhesive Label Corp.* **E-3**



Avery Automatic Labeler

Changeable Can Mixer

An improved line of changeable can mixers featuring vacuum-tight covers has been announced. The mixers incorporate double planetary stirrer action for high compression and shear, and in addition to special covers for vacuum operation, can be provided with jackets on cans for heating and cooling material during mixing. The Number 130-EL one-gallon mixer shown can be furnished with a special oversized ½- or ¾-horsepower variable speed motor drive to produce results said to be comparable to those obtainable in heavy-duty double-arm kneaders. The mixers, driven by variable speed motor drives, are obtainable in sizes from one-gallon laboratory model up to a 150-gallon working capacity size. *Charles Ross & Son Co.* E-4

Changeable Can Mixer

Shut-Off Nozzle

The OPW-Jordan automatic shut-off nozzle is equipped with an integral hold-open latch which permits the nozzle to be left unattended while filling containers. The nozzle shuts off automatically when the desired liquid level is reached. Available in ¾- and 1-inch sizes, the nozzle is made of 125 psi high-tensile aluminum alloy with stainless steel trim. *Jordan Industrial Sales Division, OPW Corp.* E-5

Continuous Mixers

A reduction in mixing time of 91 to 95 per cent is indicated by users of continuous mixing machines operating on the List system. The Ko-Kneader mixers, as the company calls them, are achieving the same degree of mixing in 3 to 5 minutes as double-blade mixers operating on cycle times of as much as an hour. A typical continuous mixer will have a production rate of 15,000 pounds per hour, while mixing only 640 pounds of material at any one time. On the other hand, a batch mixer having only one-half the hourly production rate must mix 7500 pounds of material at all times. The short retention time of the Ko-Kneader mixers, which readily adapts them to automated setups, is said to be due to: (1) the material is conveyed through the machine in "loops," (2) a large number of kneading teeth go into action as individual mixers, and (3) small quantities of material are mixed at any given time. *Chemical Machinery Division, Baker Perkins Inc.* E-6

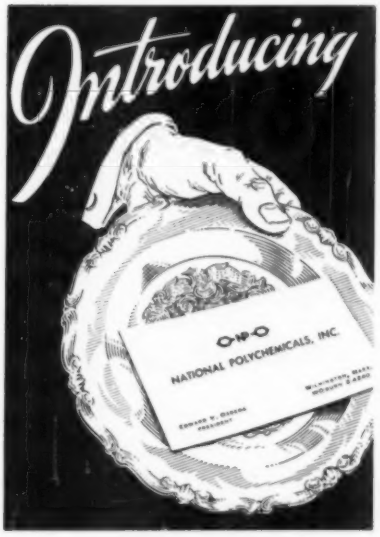
Sheet Feeder

A new sheet feeder is designed to handle a wide variety of materials such as cardboard, plastics and asbestos board. The sheets may be flat or formed (corrugated, for example), and may be rectangular or irregularly shaped. Although the feeder is used primarily to deliver sheets from piles to processing equipment, it may also be used to remove sheets from conveyors or machine tables for stacking.

The machine operates automatically on receipt of signals from an associated machine, a timing device, a sheet sensing mechanism or from the feeder itself upon discharging a sheet. The feeding cycle can also be triggered automatically. The machine can feed from piles up to four feet high at speeds up to 15 sheets per minute. Simple operating principles are said to permit rugged construction with few moving parts at a cost which will make it adaptable to many operations which formerly did not justify machine feeding. *De Florez Co., Inc.* E-7

Infra-Red Kit

Potentialities of infra-red heating in a wide variety of processing applications are said to be readily evaluated on a laboratory scale by means of a complete kit which incorporates two different light sources: a 500-watt T-3 quartz lamp with peak emssion at a wave length of 1.14 microns (near infra-red); and a 250-watt quartz Infratube with peak emission at 2.34 microns (intermediate infra-red). Also included are a compact oven which measures 4 3/16 x 10½ x 1 9/16-inches that will accommodate either of the lamps, special high-temperature hook-up wire, and instructions. The kit is designed to operate from any 110-volt line. *Lighting Division, Safety Industries, Inc.* E-8



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A A SERVICE

Subscribers to ADHESIVES AGE may now obtain, from one central source, technical literature dealing with all aspects of the adhesives industry. One or more of the books listed here may be of invaluable assistance to you. Look this list over and check the books suited to your needs.

- **Adhesive Bonding of Metals—G. Epstein. $2.95.** Considers adhesives used with metals, indicating when an adhesive-bonded joint is advantageous; the type adhesive to use; how to use it, and how to design the joint for optimum performance. ☐

- **Adhesives and Sealants in Building (Publication No. 577). Published by National Academy of Sciences. $5.00.** Twenty-two papers presented at a research correlation conference on the use of adhesives and sealants in construction. ☐

- **Adhesives for Wood—R. A. G. Knight. $5.00.** A guide and reference to the problem of joining components together. Considers components made of wood in one of its many forms and the joining of wood to metals and plastics. ☐

- **Epoxy Resins—Their Applications and Technology—H. Lee and K. Neville. $8.00.** Guide to the field of epoxy resins, covering the chemistry of their preparation and applications, including a section on adhesives. ☐

- **Polyamide Resins—Donald E. Floyd. $4.50.** Discusses in detail various important applications of the polymers belonging to the polyamide resin family and includes a comprehensive section on adhesives. ☐

- **Principles of High Polymer Theory and Practice —A. X. Schmidt and C. A. Marlies. $12.50.** Study of the principles of high-polymer theory and practice, with a section on adhesives; their applications, and mechanisms and factors involved. ☐

- **Recent Advances in Gelatine and Glue Research —G. Stainsby (Editor). $12.00.** Study of Collagen, and its protein gelatine, comprising papers and Proceedings of an International Conference of the British Gelatine and Glue Research Association. ☐

- **Rubber-to-Metal Bonding—S. Buchan. $4.00.** Discusses methods for bonding natural and synthetic rubbers to metals of all kinds, for use by those who manufacture rubber-metal units, and of interest to the rubber-minded engineer. ☐

- **Vinyl Resins—Mayo Smith. $5.75.** Surveys applications of vinyl resins with information on their types, properties, chemistry, manufacture and fabrication. Includes information on several types of adhesives in this category. ☐

- **Adhesion and Adhesives: Fundamentals and Practice—F. Clark, J. E. Rutzler, Jr. and R. L. Savage (Editors). $10.50.** Papers read at a Symposium at Case Institute of Technology and a Conference in London, on the status of knowledge in adhesion. ☐

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book reviews

Recent Advances in Gelatine and Glue Research. ***Edited by G. Stainsby.*** **Published** ***by Pergamon Press, 122 East 55th St., New York 22, N. Y. 6 x 10 in. 122 pp. $12.00.***

In recent years the group of proteins making up the collagen family has attracted increased attention and study. This family is the raw material for glue and gelatin manufacture. Members of these industries (as well as those using insoluble forms of gelatin such as tanning and suture manufacturers) have been well aware of the part research should play in their operations.

Accordingly, the gelatin and glue industry in Great Britain set up a Research Association in 1949 to carry out long-term connected researches of a fundamental type. By 1955 sufficient advances had been made in many laboratories to justify a conference. One was planned at King's College for the 1st to the 5th of July 1957. This book includes the papers presented at that conference. In fact, the subtitle is Proceedings of a Conference sponsored by the British Gelatin and Glue Research Association.

The completely technical nature of the papers points to the involved study that is being made of a completely complicated chemical material. Beginning with the Conference Lecture delivered by Dr. Linus Pauling the papers range widely over the preparation and properties of soluble collagens. The conversion of collagen to various types of gelatin, the compositions, structures and properties of gelatins and the relations of these factors to commercial usage in gelatin and glue are covered.

Dr. Pauling's lecture, "The Configuration of Polypeptide Chains in Proteins," dwells on the nature of the chemical structure of collagen. Thereafter the papers continue in an entirely cosmopolitan manner such that three are printed in French and one in German. (A paper submitted in Russian was translated by Dr. R. Truscoe and is entitled "Physicochemical Nature of Procollagen" by V. N. Orekhovich and V. O. Shpikiter.) In all, nine lectures are by Americans, two by Swedes, twenty-five by Englishmen, four by Frenchmen, two by Germans, and one each by Indian, Canadian, Russian, Israeli, Belgian and Japanese scientists.

There were five sessions: (1) Structure, Properties and Origin of Animal Connective Tissue; (2) Soluble Collagens and Molecular Weight, Shape and Structure for Gelatins and Synthetic Polypeptides; (3) Conversion of Collagen to Gelatin, and Chemical Composition; (4) Chemical and Physical Properties of Gelatin and Glue; (5) Relation of Properties to Uses. There follow Conference Notes which give the principal contributions to the Discussions. The Discussions themselves have been carefully edited and seem to carry only those parts which deal with essential new work.

Taken all in all this book represents a most thorough report of new research being completed in the field. There does not exist such detailed study anywhere else in the world and this book should bring much comprehension to the technical men in glue and gelatin.

Adhesive and Sealants in Building. ***(Publication No. 577). Published by National Academy of Sciences, 2101 Constitution Ave., Washington 25, D.C. 8½ x 11 in. 160 pp. $5.00***

Twenty-two papers presented at a research correlation conference on the use of adhesives and sealants for construction purposes are printed in full in this book. Sponsored by the Building Research Institute of the National Academy of Sciences, the conference, which was held on December 4-5, 1957 in Washington, D.C., was designed to offer the most complete picture possible on the present status of adhesive materials in the building industry. The book, like the conference, is divided into five sections.

The first section, an introduction, contains five papers on basic information and applications: "The Importance of Adhesives and Sealants in Building," by Alfred G. H. Dietz; "Adhesives," by George W. Koehn; "Sealing Compounds and Tapes," by Gordon E. Hann; "Preformed Gasketing Materials and Tapes," by Herbert F. Kleinhans, and "Pressure-Sensitive Tapes," by Martin H. Gerstel.

Part II, on "Sealing Joints in the Building Exterior," is composed of two sub-sections. The first, on traditional materials, contains two papers: "Glazing Light-Transmitting Materials," by Robert W. McKinley, and "Calking Compounds," by Walter C. Aberth. The second, on metal curtain walls, presents papers on "Sealing Compounds and Gaskets," by C. R. McNamara and "Butyl Compounds for Curtain Wall Sealants," by R. J. Kraynick.

Part III, "Adhesives for the Building Interior," is composed of three papers: "Adhesives for Floor Surfacing Materials," by R. B. Rohrer; "Adhesives for Walls, Ceilings and Work Surfaces," by John W. Bruce, Jr., and "Adhesives and Sealants in Buildings' Service Systems," by Charles T. Rairdon.

The fourth section, "Adhesives for Structural Materials and Components," is also divided into two parts. The first, on cementitious materials and lumber products, contains three papers: "Bonding Agents for Cementitious Materials," by Daniel J. Goeke; "Wood Laminated Structural Members," by Robert E. Eby; "Glued Structural Members and Assemblies," by R. P. A. Johnson. The second part, on sandwich panels, offers two papers on "Types of Adhesives for Sandwich Panels," by George J. Schulte, and "Skins, Cores and Fabrication of Panels," by Jack M. Roehm.

The last section, "The Future of Adhesives and Sealants in Building," contains six papers: "Structural Adhesives for Metals," by Harry C. Engel; "Adhesives for Plastics," by Harold F. Wakefield; "Tapes for Building Panels," by Paul H. Wilson; "New Adhesives for Wood," by C. D. Dosker; "Summary of Conference Papers," by Walter C. Voss, and "Conference Round-Up," by William H. Scheick of the Building Research Institute.

A Successful Pioneer Effort

This book represents the first major effort at correlation of research data in the adhesives field as applied to buildings. It is a successful pioneer effort. The sponsors of the symposium are to be commended for securing a panel broadly representative of the building and adhesives industries, and one which at the same time manifests a consistently high degree of competence. The caliber of the papers on the whole is excellent. A large amount of basic information is included by the various authors, who in toto offer a valuable survey of the use of adhesives and sealants in building.

The editors are also to be commended for including in full the question-and-answer sessions which followed each panel discussion. The practical information sought by members of the audience has a particular relevance to the needs and problems of those working with adhesives in the structural fields, and is indicative of the trends which thinking in this field is taking. Incidentally, the layout and printing are of high quality, and a generous use of photographs, schematic diagrams and graphs supplements the text to excellent advantage.

Trade Literature

Shoe Adhesives. This catalog is devoted to the products of a large chemical concern which caters exclusively to the shoe and leather industry. The chemicals discussed fall broadly into four categories: adhesives, dressings, cleaners and leather treating oils. The various individual adhesives, classified according to the departments in which they are used, are listed. The purpose, method of application and an indication of type are listed for each. Photographs depict the various research, manufacturing and storage facilities of the company. *American Finish & Chemical Co.* **L-1**

Fungicides and Preservatives. This brochure describes 24 fungicides and preservatives, many of which find large scale application in the adhesives industry. Three tables are presented. One, devoted to solubilities, gives data on various solvents in which the chemicals can be dissolved, with information on characteristics of the decomposing action and the resulting solutions. Another is devoted to anti-microbial activity, with percentages of the materials necessary for inhibition of specific microbes. The other shows the average per cent employed (by weight) for preservation of different products, including adhesives. The last page is devoted to text on characteristics and applications of the solutions of some of the fungicides, toxicities, phenol coefficients, and literature references. *Chemo Puro Manufacturing Corp.* **L-2**

Plastics Adhesives. This booklet covers the company's complete line of adhesives, coatings, anti-static agents, cleaners, lubricants and related products for use with plastics, wood, metal, glass and other materials. Adhesives for use with the following are described: acrylics; cellulose acetates; cellulose nitrates; nylon; phenolics, ureas and melamines; polyesters and epoxies; polystyrene and vinyl. A brief description with physical properties and setting characteristics is given for each adhesive. A chart provides a guide for choosing the suitable adhesive to bond combinations of the various materials. *Chemical Development Corp.* **L-3**

Electronics Products. This booklet is provided with an attachment for insertion of the one-page technical bulletins issued by the company on its products. These include adhesives, cements and sealants, casting resins, plastic foams, plastic rods and sheets, plastic surface coatings, impregnating resins, laminating resins, ceramic dielectrics and nuclear radiation shielding materials. In each bulletin a general description, a list of physical properties, instructions for use and other relevant data are given. Folded loose in the cover is a large wall chart on which for each material the following are detailed: physical properties, electrical properties, interesting features (maximum and minimum temperature applicable for each, major physical characteristics, outstanding properties and cost range), major uses and general remarks. *Emerson & Cuming, Inc.* **L-4**

Chemicals for Adhesives. This booklet offers 63 formulas for adhesives of different kinds, with information on preparation procedures and a list of specific materials to be bonded by each. Featured is a special index in which a formula for a specific bonding application (abrasives to cloth, aluminum to glass, asphalt to vinyl coated objects, etc.) using a specified type adhesive (hot melt, solvent or emulsion) may be easily located. Also included are sections on sprayable adhesives and on emulsion type adhesives, each of which also contains formulas. Excellent basic material for the adhesives formulator. *Neville Chemical Co.* **L-5**

Dutch Brand Adhesives. This short but attractive publication provides a bird's eye view of Johns-Manville adhesive products, manufacturing facilities and customer services. A schematic diagram portrays a portion of the company's Chicago plant, which is also described in the text. The booklet closes with a list of customer services. An effective use of color and artwork enhances the presentation. *Dutch Brand Division, Johns-Manville Co.* **L-6**

Temperature Detectors. Complete information about Thermohm detectors (resistance thermometers) for temperatures up to 1000° F. is contained in this 36-page catalog. The catalog describes how these primary elements are being used for many applications in various industries. A special section describes use for precise laboratory work involving temperatures from −261° to 500° C. *Leeds & Northrup Co.* **L-7**

Consulting Service. The services available from a consulting chemical firm located in Central Florida are described in this illustrated brochure. Details of formulation and product development operations are given. *Florida Chemists and Engineers, Inc.* **L-8**

FOR MORE INFORMATION on the trade literature reviewed here, use the Reader's Service Card elsewhere in this issue.

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